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LASS-II Rapid Geodetic Survey System (RGSS)

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Engineer Topographic Laboratories
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FINAL TECHNICAL REPORT

FOR

LASS-II RAPID GEODETIC SURVEY SYSTEM (RGSS)

DID-S-4057

Prepared for

DEPARTMENT OF THE ARMY

Under

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This ~~final~~ Technical Report presents the progress to date on the conversion of a standard U.S. Army Position and Azimuth Determining System (PADS AN/USQ-70) to a Litton Auto Surveyor System Dash II (LASS-II) to a Rapid Geodetic Survey System (RGSS). Multiple efforts have been initiated for this contract requirement as follows:

1. Perform the non-recurring Engineering design for conversion of a LASS-II to an RGSS.

2. Perform the necessary real-time software mechanization changes to enable an RGSS to attain the following performance goals:

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a. Interim Goal: Map the gravity disturbance vector to 0.3 sec (RMS) for the deflection components and 0.5 milligal (RMS) for the gravity anomaly.

b. Long Term Goal: 0.1 sec (RMS) for the deflection component and 0.1 milligal (RMS) for the gravity anomaly as the ultimate goal.

3. In depth investigation of RGSS real-time software definitions, output parameters expansion, and computer simulations for validation of the on-line software mechanization.

Hardware changes, real-time software modifications and definitions are contained herein to attain the interim and ultimate performance goals. This final report discusses the software changes generated along with the hardware changes made to date. Although the hardware changes discussed herein are not necessarily the final configuration, the drawing package submitted under a separate CDRL line item will be definitive for permanent record of all hardware modifications initiated and finalized.

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PREFACE

This document is generated under Contract DACA 72-84-C-0003 for the U.S. Army Engineer Topographic Laboratories, Ft. Belvoir, Virginia 20060 by Litton Guidance and Control Systems Division, Woodland Hills, California 91365 and submitted as Document Number 469440A. The Contract Officer's Representative is Mr. Ed Roof.

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TABLE OF CONTENTS

Litton GUIDANCE & CONTROL SYSTEMS
5500 Canoga Avenue, Woodland Hills, California 91365

FSCM 06481

TABLE OF CONTENTS (cont)

Litton GUIDANCE & CONTROL SYSTEMS
5500 Canoga Avenue. Woodland Hills, California 91365

FSCM 06481

LIST OF ILLUSTRATIONS

LIST OF TABLES

GUIDANCE & CONTROL SYSTEMS
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1.0 SCOPE

1.1 Purpose

The objective of this report is to identify those hardware changes effected and or changed as defined in the interim report.

1.1.1 Incorporated Hardware Changes.

a. Installation of A1000 accelerometers in the horizontal axes.

b. The Quantizer assembly was changed to accommodate the A1000 accelerometer.

c. A mass unbalance compensation amplifier was added to reduce first order acceleration effects on the gyros.

d. Accelerometer thermal overdrive circuitry was added and subsequently removed.

e. Platform (stable element) wiring was modified by removal and addition of wires in the harness to reduce harness size.

f. IMU harness wiring and Quantizer were modified to isolate the accelerometer grounds from the general ground tree to reduce cross coupling effects.

g. The IMU external cables. W5, W4 and W2 were lengthened to 24 feet. An addtional modification to W5 allows the rapid disconnect whereas the original design made the cable captive to the pallet.

Reference Addendum 1 for the documented hardware changes. Specific build configurations have been modified and are included as ECNs against the original documents. For explicit build, reference specific drawings as indicated on the Engineering RGSS-II Family Tree.

1.1.2 Incorporated Software Changes

a. Modifications to the Kalman Filter.

b. Modifications to the Alignment.

c. Ability to decouple the Kalman Filter Position Updates.

d. Addition of Gyro and Accelerometer Turnaround Compensation Tables.

e. Expansion of the MARK Table.

f. Modification of Control and Display Unit (CDU) Input/Output Parameters for RGSS.

g. Expansion of RAP Data Output Parameters.

1.1.3 Off-Line Data Post Processing and Analysis

a. Define C&D Gyro Coefficient Parameters, Second-Order Inverse Meridional Radius Computations, and Gravity Formula.

b. Define Outputs for Off-Line Smoothing.

c. Performance of Computer Simulations to Validate On-Line Software.

The follow-on phase will initiate the necessary hardware changes to produce an RGSS for field operation, to be employed in a land vehicle or helicopter and operated along any trajectory, with a capability of measuring the gravity anomaly with an accuracy as follows:

(1) Interim Capability Goal

0.3 sec, RMS, in deflection

0.5 milligal, RMS, in intensity

(2) Long-term Capability Goal

0.1 sec, RMS, in deflection

0.1 milligal, RMS, in intensity

1.2 Planned Modifications

Engineering efforts were directed to upgrade a government furnished PADS system to an RGSS system. These modifications include both hardware and software changes. The hardware modifications included replacement of the A200 series accelerometers with A1000 series accelerometers, and associated circuit changes to enable compatibility. Cable modifications enable the removal of the IMU from the host vehicle so motion disturbances during ZUPTS will be minimized. Software changes encompass level and vertical axis Kalman filter error models that were incorporated with the preliminary RGSS study. In addition, CDU display resolutions and

format changes have been incorporated. The program data base has been expanded to include turnaround error tables for all accelerometers.

2.0 DESIGN REQUIREMENTS

2.1 General

The following dissertation shall encompass the engineering efforts related to the Rapid Geodetic Survey System (RGSS) mechanical and electrical design requirements as defined by the Engineering Project Plan dated September 1984 and the job analysis requirements dated 1 September 1983.

Baseline efforts require procurement of a government furnished system designated as the Litton system, part number 880500. This system is known as Position Azimuth Determining System (PADS).

The effort is, in effect, a continuing effort of the Defense Mapping Agency and Department of the Army directed through the U.S. Army Engineer Topographic Laboratories of Fort Belvoir, Virginia.

2.1.1 Features. Prominent features of the PADS modifications are as follows:

a. Replacement of existing A200 level axis accelerometers with A1000 accelerometers.

b. Capability of locating the operational Inertial Measuring Unit (IMU) within a 20 foot radius of the rest of the system.

c. Circuitry modification accommodating the change of accelerometers.

2.1.2 Software Modifications. Software modifications incorporated.

a. Minibias update - Z gyro axis. The software has been mechanized such that Z gyro bias updates shall be added as a minibias in proportion to the mission time or on time and measured between azimuth updates at the beginning and close of a mission. The proportional value of bias shall be used for succeeding alignments and navigation runs.

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b. Calibration constants. The data base has been expanded to add sixteen words for the X and Y accelerometer heading sensitive biases. The biases shall be calibrated at each 22.5 degrees. The error curve shall be considered linear between points for interpolation.

c. Marks. The Mark table has been increased from 30 (thirty) to 50 (fifty). The Mark records include gravity measurements of 1) magnitude, 2) deflection NORTH/SOUTH and 3) deflection EAST/WEST. Additional information included in the table and subsequent records are total station mark, horizontal angle from total station, zenith angle from total station, delta elevation of total station to ground and distance from total station to mark.

d. CDU Routines. CDU routines have been modified to accommodate gravity inputs deflection and magnitude and Gravity Missions utilizing smoothed data or off-line RAP, which will record raw data only.

e. Laser ranging inputs on the IEEE-488 Bus shall be processed for ranging (altitude) information with corresponding operator queing and notification.

f. Level axes Kalman mechanization includes the following modifications:

(1) Initial Platform Tilt Variance

(2) Initial Platform Drift Rate Variances

(3) Initial Platform Azimuth Misalignment Variance

(4) Initial Covariance Between Azimuth Misalignment and East Gyro Drift Rate

(5) Platform Drift Rate Correlation Times

(6) Platform Drift Rate White Disturbance Noise Power Spectral Densities

(7) Null Velocity Random Observation Error

g. Modifications for the vertical axis Kalman mechanization are as follows:

(1) Null Velocity Random Observation Error

(2) Vertical Axis Quantizer Rectification Error Variance and White Disturbance Noise Power Spectral Density

2.2 Gyro and Accelerometer Screening Requirements

Gyros and accelerometers were screened from the overall population in accordance with the parameters that follow. Engineering further tested and selected those instruments that exhibited characteristics required for RGSS accuracy. Characterization of the instruments at the unit level were documented on standard data sheets and strip chart recordings such that correlation to system level performance may be made at a later date.

2.2.1 RGSS Gyro. The RGSS gyros were screened to the standard LASS-II gyro, part number 659730-6 (ES 880977) with additional requirements as noted in table I.

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TABLE I. ADDITIONAL RGSS GYRO SCREENING

Applicable Paragraph	Function	Requirements Differing from ES 880977
3.3.1.5.2	Floatation temperature	0.5°F to 1.5°F 152.0°F minimum
3.3.2.3	Random drift triad turn on + 1 hour to turn on + 8 hours	I.G. = 0.0001 ±.0002°/hr^2 O.G. = 0.0003 ±.0005°/hr^2
3.3.2.5	Temperature sensitive drift rate	H.A. = 0.01°/hr/°F V.A. = 0.015°/hr/°F
3.4.1.1 3.4.1.2	Torquer alignments	<60 sec (both axes)
3.4.2.1 3.4.2.2	Spin axis alignments	<30 sec (both axes)
None	Cross axis sensitivities for 2000°/hr rate about the vertical precession axis	<1°/hr H.A. precession axis drift
3.3.4.2.3	Long Term Bias Stability (30 day)	H.A. = <0.0005°/hr/day V.A. = <0.001°/hr/day
None	Torquer Scale Factor Variation Long Term	<0.02% over 90 days
None	Torque Scale Factor Temperature Sensitivity	<0.03%/°F
None	Torquer Scale Factor Asymmetry	<0.01%

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2.2.2 Accelerometer

The RGSS accelerometer were screened to the PADS accelerometer, part number 679770-6 (ES679765) with additional requirements as noted in table II.

TABLE II. ADDITIONAL ACCELEROMETER SCREENING

Applicable Paragraph	Function	Requirements Differing from ES679765
3.1.1.	Operating Temp.	151 ±2°F
3.4.2.2	Bias Stability Temp	<10 μg 1σ at operating temp (151°F)
3.4.2.3	Bias Temp. Sensitivity	2 μg/1°F between 140°F and 160°F
3.4.2.5	Bias Cage - Uncage Repeatability	<10 μg
3.4.3	Scale Factor	0.300 ±.003v/g across 200Ω ±.001°/°
3.4.3.2	Scale Factor Non linearity (Kii)	<50μg/g^2 0-4g's
3.4.3.4	Scale Factor Long Term Stability	<200 PPM/30 days
3.4.4	Axes Alignment	<30 arcsec
3.4.1*	Threshold Acceleration	1μg
3.4.2.2*	Bias Stability	Random drift 1-6 hours
	Bias Repeatability	<10μg at temperature turn-off-turn-on
	Hinge Creep	Turn on +20 minutes. Creep shall be non-identifiable
	Overnight drift runs	Monitor for abnormalities including spurious noise spikes and bias steps.
	Scale Factor asymmetry	Monitor and obtain asymmetric value.

*Engineering shall further check and/or verify.

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2.3 Hardware Modifications

2.3.1 Level Axis Accelerometer. Level axis accelerometer changes from the floated A200 series to the dry A1000 series required circuit modifications. The extent of circuit changes were kept within the IMU. The first of the changes required a quantizer input scaling and feedback circuit change, which is limited to the removal of six capacitors and a change of resistance values on 22 resistors. This, then, maintains the X and Y axis scale factors at 7.623 ±0.3% volts/ft/sec as it was before. An additional operational amplifier with an adjustable gain was required to satisfy the quantizer - interpolator output scaling of .613 V/Pulse. The housing for the A1000 accelerometer is made of Hi Mu 80 steel and annealed. The housing external dimensions are the same as the A200 case, this allowing existing A200 heater and flexprint use. The mass of the new housing, including the A1000 accelerometer, is the same as the A200 accelerometer (<200 gms).

The case design is such that minimum soldering will allow easy access to the A1000 should the need arise.

2.3.2 A1000 Accelerometer. The A1000 accelerometer, not being configured electrically as the A200, required an additional amplifier to provide gyro mass unbalance compensation terms. An uncompensated gyro may have 'g' sensitive drift rates up to 8 degrees per hour. The amplifier provides a nominal output of 1.72 v/g commensurate with the A200 accelerometer, and provides buffering, such that the accelerometer-quantizer loop is not dynamically affected.

2.3.3 Platform. The platform or gimbal assembly had all A200 accelerometer associated wiring, which is not usable to the A1000 accelerometer. The accelerometer-restoring amplifiers used with the A1000 accelerometers have the restoring amplifier mounted on the accelerometer; hence, there were no additional restoring amplifier requirements. The A200 accelerometer-restoring amplifiers were removed and the previously mentioned mass unbalance compensation amplifier which was designed with the same mechanical footprint of the A200 restoring amplifier was located within the stable element structure in one of the vacated A200 accelerometer-restoring amplifier locations. New wires were added to the stable element harness to support the A1000 accelerometer and mass unbalance compensation amplifier.

2.3.4 Mount Requirements. The Hardware design included an IMU mount which could be attached to a "Lazy Susan" table. This design allows access to an operational IMU. The IMU shall be mounted on a plate which has four quick disconnect latching mechanisms to retain it on a frame assembly. The IMU power and signal cables have been lengthened to twenty feet. This will

enable the IMU to be placed in an area remote to the vehicle, eliminating vehicle motion and engine vibration inputs. Twenty feet was chosen as a creditable length based on vehicle surveys at the Litton facilities.

2 4 RGSS System Test Plan

2.4.1 General. Reference report ETL CR-74-16, Litton 404856. System testing shall parallel the efforts generated for the initial test program for the gravity anomaly measurements, conducted by Litton and the U.S. Army Engineer Topographic Laboratories.

The static system testing will investigate and calibrate the following:

a. Turnaround effect of east (E), north (N) and azimuth (Z) gyro bias.

b. Turnaround effect of E, N and Z accelerometer bias.

c. Thermal tests to ascertain overall system stability.

d. System test along an established IPS test course. The IMU shall be removed from the host vehicle and placed over the point that the anomaly is to be measured.

System vibration testing will be performed during initial tests. Any significant gyro bias step due to vehicle vibration when moving would affect the accuracy of deflection of measurements due to the resulting stable element tilt. An accelerometer bias step due to vibration is less critical since the effect on deflection measurements is reduced when vibration is reduced at vehicle stops. However, there will be an effect upon position accuracy. Testing will measure the bias shift of the E, N, Z gyros and the E, N, Z accelerometers due to vibration.

An additional parameter which will be needed to determine the vibration level to be experienced by the instrument given the vibration level of the vehicle is the translational transmissibility of the IMU from the external mounting surface to the stable element. This data will be obtained during vibration testing.

2.4.2 Base-Line Test. Perform a normal full system calibration except for turnaround. Next, to confirm that the modified system is still capable of maintaining constant bias values over an extended period of time, allow the system to reach final thermal stability (several hours if required). Measure east, north and z gyro drift (BE, BN, BZ) and Z accelerometer bias (BAZ). BE, BN and BAZ are measured by plotting on the strip chart, the program

estimates of these values, with the align loop held in MODE 2, with selected low gains. BZ is calculated from the slope of the plotted AZAV, the (freely drifting) azimuth resolver output. Over a 24 hour period the drift change in 1 hour should be less than

BE	0.0004 deg/hr (1σ)
BN	0.0004 deg/hr (1σ)
BZ	0.0024 deg/hr (1σ)
BAZ	0.1 μg (1σ)

2.4.3 Gyro Drift Turnaround Testing. Utilizing the operational program with patches (TBD), perform the test that computes the upper gyro turnaround testing, followed by the lower gyro. The tests shall be run a minimum of three times to verify stability of the computed errors. Interruptions of a test shall not occur once the test has been initiated.

2.4.4 Z Accelerometer Turnaround Testing. Utilizing the operational program with patches (TBD), perform the Z accelerometer bias as a function of heading. The test shall be run a minimum of three times to verify stability of the computed errors.

2.4.5 Level Accelerometer Turnaround Testing. Measure east and north accelerometer bias (BAE, BAN) as described below. Load gyro drift turnaround tables with values determined in paragraph 2.4.3.

Plot east and north velocity (VE, VN) on the strip chart. Allow the system to settle in Mode 2. Set gains to zero to put system in free inertial mode. (A software patch will be added to make this convenient.) Turn the IMU case to the next heading and observe velocity plots for a ramp. Allow to run for 5 minutes. Set gains back to normal and allow loops to settle at this new heading. Repeat for each heading. The initial heading is 0° with fifteen subsequent heading increments of 22.5°. See figure 1 for typical velocity plot. The tests shall be repeated three times. Turnoff and turn back on is only allowed between tests or between repeats of tests.

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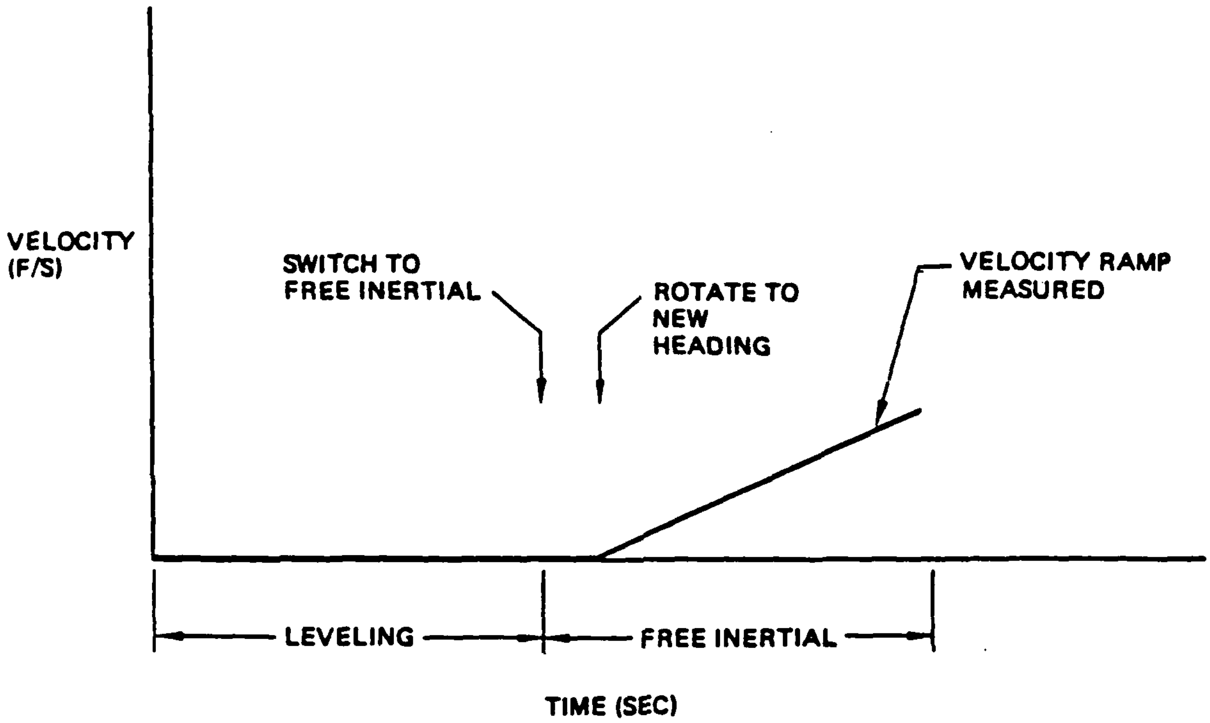

Figure 1. Typical Velocity Plot for Horizontal Accelerometer Heading Sensitivity Testing

2.4.6 System Testing Along IPS Test Course. A test course was established by the Defense Mapping Agency (see figure 2) for the testing of the Inertial Positioning System (IPS). A gravity survey which measured the vertical component of gravity with a gravity meter was also conducted. The IPS course consists of 12 survey control points distributed over a course of approximately 30 miles. Gravity control was established at these points and five intermediate values between adjacent points were also established. These gravity measurements shall be used as a basis to determine the error of the RGSS system.

2.5 System Analysis and Simulation Program Plan

a. Real-Time Software Changes. Area of investigation for real-time software changes are as follows:

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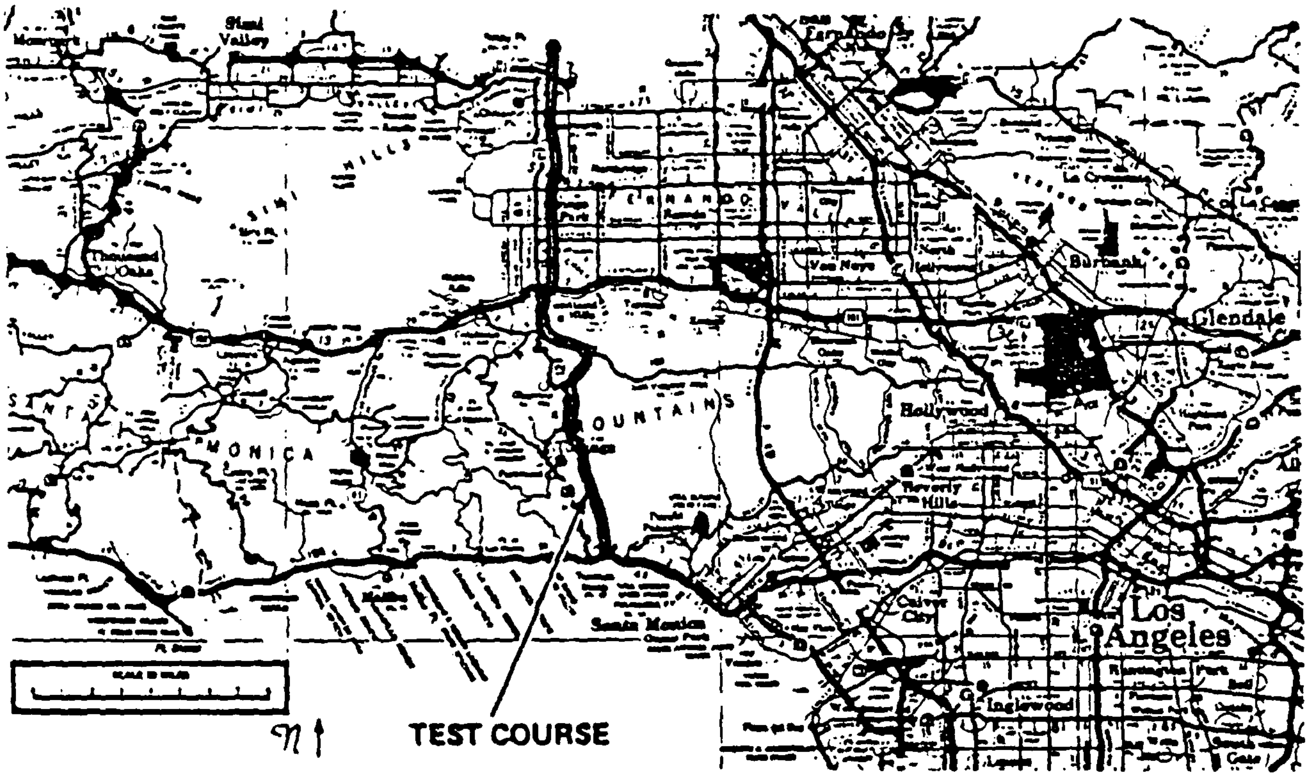

Figure 2. Inertial Positioning System Test Course

(1) Definition of C and D gyro coefficient parameters.

(2) Definition of the second-order inverse Meridional Radius Computation.

(3) Accommodation of the deflection of the vertical insertion.

(4) Definition of the gravity formula.

b. Changes in Recording of RGSS Survey Measurements.

c. Validation of the On-Line Software.

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2.6 RGSS Real-Time Software Changes

2.6.1 Definition of C and D Gyro Coefficient Parameters. The C and D, which represent the coefficients between the azimuth gyro bias (b_z) and Easting and Northing error, respectively, have been derived in Reference 1. The current mechanization is replaced with a new procedure which can be described as follows:

At $t = 0$, set EIPNI, EIPEI = 0

If ($V = 0$) go to 1:

$$\Delta\phi = \phi(T) - \phi(0)$$

$$\Delta\lambda' = [\lambda(T) - \lambda(0)] \text{ Cos } \frac{[\phi(T) + \phi(0)]}{2}$$

$$\text{EIPNI} = \text{EIPNI} + \Delta\phi \cdot \Delta T$$

$$\text{EIPEI} = \text{EIPEI} + \Delta\lambda' \cdot \Delta T$$

$$D = T \cdot \Delta\lambda' - 2 \cdot \text{EIPEI} \quad \text{(rad-sec)}$$

$$C = T \cdot \Delta\phi - 2 \cdot \text{EIPEI} \quad \text{(rad-sec)}$$

1: (Continue with program) This mechanization will inhibit the integration during stops, i.e. velocity (V) = 0.

2.6.2 Definition of the Second-Order Inverse Meridional Radius Computation. The meridional radius inverse is given as:

$$\frac{1}{R_m} = \frac{(1-\varepsilon^2 \sin^2\Phi)^{3/2}}{a(1-\varepsilon^2)}$$

where

a = equatorial radius

Φ = Geodetic latitude

$$\varepsilon^2 = 1 - [\frac{b}{a}]^2 \quad \text{Eccentricity}$$

$$= 1 - (1 - f^2)$$

Reference 1: IPS Smoothing program Mechanization equation, J.R. Huddle, JRH-7405-028 23 May 1974.

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For real-time computation purposes, the formula stated above is expanded using the binomial expansion,

$$(1 \pm X)^n = 1 \pm nx + \frac{n(n-1)X^2}{2} \pm \text{- - - - - -} \quad .$$

To obtain the accuracy required, the second-order inverse meridional radius will be implemented in the real-time computer program. Using the binominal expansion, the second-order inverse meridional radius is given as

$$\left.\frac{1}{R_M}\right|_{o(2)} = \frac{1}{a} \left[1 + \varepsilon^2\left(1 - \frac{3}{2} \operatorname{Sin}^2\Phi\right) + \varepsilon^4\left(1 - \frac{3}{2} \operatorname{Sin}^2\Phi + \frac{3}{8} \operatorname{Sin}^4\Phi\right)\right]$$

2.6.3 <u>Accommodation of the Deflection of the Vertical Insertion.</u> <u>The East-West (η) and North-South (ξ) deflection of the vertical</u> components will be entered in arc-seconds through the Control and Display panel and employed in the real-time software so that the platform is physically leveled to the reference ellipsoid. The sign conventions are as follows:*

$\xi > 0$ means this deflection is toward the south and would normally cause a negative east platform tilt. Astronomic latitude exceeds geodetic latitude.

$\eta > 0$ means this deflection component is toward the west and would normally cause a positive north platform tilt. East astronomic longitude exceeds east geodetic longitude.

The above quantities must be converted to radians and multiplied by the nominal value of gravity so that they are in the same units and at the same scale as the deflection estimate quantities DN, DE in the existing program. They are then employed to initialize DN and DE as follows:

$$DN = -g \cdot \xi$$

$$DE = -g \cdot \eta$$

*This data should be entered after calibration and alignment when the east and north accelerometers are directed east and north, respectively.

Additionally, the computed north gravity component term g_N should be eliminated since by definition all level gravity components are included in the deflections of the vertical.

2.6.4 Definition of the Gravity Formula. The gravity anomalies are computed using the following theoretical gravity formula associated with the WGS-72 system:

$$\gamma = 978033.26\,(1 + 5.3165822 \times 10^{-3}\sin^2\Phi$$

$$- 5.8614731 \times 10^{-6}\sin^2 2\Phi)$$

$$- 2H^*go/a \quad \text{mgal}$$

where the last term is elevation (H) compensation.

The parameters used for the formula stated above are for WGS-72 ellipsoid:

a = Equatorial radius = 6378135 meters

f = Earths flattening = 1./298.26

g_o = Equatorial gravity = 978.03326 gal

Ω = Earth sideral rate = 7.2921151×10^{-5} rad/sec

2.7 Changes in Recording of RGSS Survey Measurements

In the existing RAP, four input units are required; namely, unit 5, unit 7, unit 8 and unit 9. Unit 5 contains two optional specifiers which will be selected off-line. Unit 9 contains personality identification (ID) of each module and will be input off-line. For RGSS on-line software recording, the contents of unit 7 and unit 8 have to be recorded by on-line software.

2.7.1 Unit 7 Input Requirement. Unit 7 contains the computed position and gravity data from on-line software. At the end of each stop period, there are 14 variables which shall be recorded from on-line software as follows:

a. Station ID

b. t = time at the end of a stop period

c. Φ_i^C = system latitude (deg, min, sec)

d. λ_i^C = system longitude (deg, min, sec)

e. H_i^C = system elevation (meters)

f. y_i^C = system E-W deflection (μg)

g. J_i^C = system N-S deflection (μg)

h. δg_i^C = system disturbance (mgal)

i. C^C = gyro modeling coefficient

j. D^C = gyro modeling coefficient

2.7.2 Unit 8 Input Requirement. Unit 8 contains the reference position and gravity data needed to be recorded from on-line software. At each control point, the following information shall be recorded:

a. Station ID for each control point

b. Φ_i^R = reference latitude (deg, min, sec)

c. λ_i^R = reference longitude (deg, min, sec)

d. H_i^R = reference elevation (meters)

e. y_i^R = reference E-W deflection (μg)

f. ξ_i^R = reference N-S deflection (μg)

g. δg_i^R = reference disturbance (mgal)

2.7.3 Additional Data to be Recorded. Since the following data is of interest at each vehicle stopping point to enhance the overall system performance, it will be necessary to mark each vehicle stopping (Zupt) point. The following additional data shall be recorded:

a. Vehicle heading

b. Azimuth resolver change during stop-time

c. Sum of all velocity observations (all three axes) used by Kalman filter for correction during the stop.

d. Sum of all position corrections (all three axes) applied by Kalman filter during the stop.

e. Sum of all deflection estimated updates applied by Kalman filter during the stop.

f. Sum of all gravity anomaly estimate updates applied by Kalman filter during the stop.

g. At the end of each stop, the system status vector.

2.8 Validation of the On-Line Software

The filter validation plan involves mechanizing the Kalman filter covariance propagation simulator, exercising the mechanized simulator, and verifying performance.

2.8.1 Mechanization of the Kalman Filter Covariance Propagation Simulator. A simulator has been coded with an HP9836 to propagate the Kalman filter covariance matrix. The program consists of a trajectory, generator and a filter covariance propagator. The covariance propagator is driven by the given trajectory.

2.8.2 Validation of the On-Line Kalman Filter. The simulator mentioned in 2.8.1 will be exercised via a reference scenario to validate the on-line RGSS Kalman filter. The reference scenario is yet to be defined.

2.8.3 The Operational Option of the On-Line Smoother. It is understood that, in the RAP application, the data resulting from on-line software should not have the position update on the Kalman filter. However, for some applications, it might be desirable to have position update on the Kalman filter at a control point, since the misclosure is a variable. For this consideration, it has been discussed and suggested that the RGSS on-line software should have the following options:

a. For RAP applications, the Kalman filter shall be decoupled completely from the on-line smoother. In this case, the zero velocity updates and the on-line smoothing will be accomplished but the Kalman filter will not be disturbed by position misclosure at any control point (i.e., no position update with the Kalman filter).

b. For non-RAP applications, in addition to the zero velocity updates and the on-line smoothing, the Kalman filter will be exercised by position misclosure at a control point (i.e., with position update with the Kalman filter).

Figure 3 shows the flowchart for the two options discussed above. Table III shows the Kalman mechanization changes.

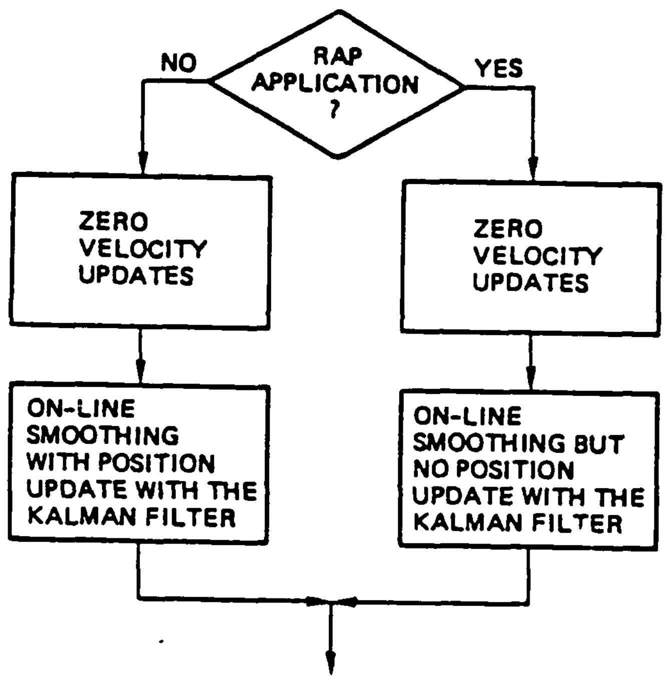

Figure 3. Two Operational Options for the On-Line Software

2.9 Alignment Modifications

2.9.1 Radii Calculation

2.9.1.1 Earth Flattening. Earth Flattening (f) is described, using the semi-major axis of the meridional ellipse (a) and the semi-minor axis or polar axis (b), as $f = \frac{a-b}{a}$, also Earth Eccentricity (ε^2) is described as:

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TABLE III. KALMAN MECHANIZATION CHANGES

Variable	Function	LASS-II	RGSS
	(Horizontal Kalman)		
P55	X-Tilt	$10AS^2$	$.1AS^2$
P66	Y-Tilt	$10AS^2$	$.1AS^2$
P1111	X-Accel	$25.5\mu g^2$	$.5\mu g^2$
P1212	Y-Accel	$25.5\mu g^2$	$.5\mu g^2$
P88	X-Gyro Drift	$P88+.001°/HR^2$	$10^{-5}°/H^2$
P99	Y-Gyro Drift	$P99+.008°/HR^2$	$10^{-5}°/H^2$
P1010	Z-Gyro Drift	$P1010+.001°/HR^2$	$10^{-5}°/H^2$
P77	Z-Tilt	$P77+15AS^2$	$.3AS^2$
P78	Azimuth Misalignments: X-Drift	$15COSPHIx40AS^2$	0
A88	Dynamics Element	-1/14400S	0
A99	Dynamics Element	-1/14400S	0
A1010	Dynamics Element	0	0
Q8	X-Drift Noise	$2x.0015°/H^2/7200S$	0
Q9	Y-Drift Noise	$2x.0015°/H^2/7200S$	0
Q10	Z-Drift Noise	$2x.005°/H^2/7200S$	0
KRVEL	Velocity Observation Noise	$.003F/S^2$	$.001F/S^2$
Q11	Accel Noise	$2x8\mu g^2/2400S$	$2x24\mu g^2/2400$
Q12	Accel Noise	$2x8\mu g^2/2400S$	$2x24\mu g^2/2400$
	(Vertical Kalman)		
KRVEL	Velocity Observation Noise	$.003F/S^2$	$.001F/S^2$
KPV44	Rectification Error	$10\mu g^2$	$10\mu g^2$
KQV4	Rectification Noise	5.737991E-11	8.0E-11
	(Horizontal Kalman)		
KA73	Dynamics Element	TANθ/R	0
KA56	Dynamics Element	WZ	0
KA57	Dynamics Element	-WY	0

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$\varepsilon^2 = \frac{a^2 - b^2}{a^2}$. The approximation $\varepsilon^2 = 2f$ has been replaced with

the calculation of ε^2, and higher order terms in the binominal expansion have been kept, allowing greater accuracy in the computations of meridional and polar radii.

2.9.1.2 Nav Spheroid. Nav Spheroid (Clark 1866) to selected spherical transformations have been eliminated and the navigation equation will now use selected spherical constants (1/a and ε^2).

Spheroids	Select Number
1	Clark 1866
2	Clark 1880
3	International
4	Bessel
5	Everest
6	Malayan
7	Australian National
8	WGS-72

2.9.1.3 Additional Kalman Mechanization Changes. *Radius of curvature is now defined as:

$$AN = 1/a[1-h/a(1-\varepsilon^2 SIN\theta^2)+\varepsilon^2(-\tfrac{1}{2} SIN^2\theta)+\varepsilon^4(-1/8 SIN^4\theta)]$$

$$AE = 1/a[1-h/a(1+2(\varepsilon^2-3/2\varepsilon^2 SIN\theta))+\varepsilon^2(1-3/2 SIN^2\theta+\varepsilon^4(1-3/2 SIN^2\theta)+ 3/8\varepsilon^4 SIN^4\theta]$$

a. North gravity to Y-accelerometer low frequency deflection compensation was $2.578E-3-4.4073E-4xSIN\theta^2-1.655E-8xHxCOS\theta SIN\theta$

- This function is now deleted

b. Deflection input before alignment:

(1) ξ (N-S) is positive for gravity vector deflected north

(2) η (E-W) is positive for gravity vector deflected east

*Reference Memo: A.J. Brockstein, 24 June 1981, Title: "Second Order Approximations to the Radii of Curvature."

(3) Y-accel compensation is then: G_LxX-TILT+CORIOLIS(Y) + Y-permanent bias+gravity anomaly+rectification bias + Y-vibration bias-ξ(N-S)xG_L

(4) X-accel compensation: G_LxY-TILT+CORIOLIS(X)+ X-Permanent bias+gravity anomaly+rectification bias + X-vibration bias-η(E-W)xG_L

$$G_L = Go + .1699 SIN\theta^2 \frac{-2H}{a}Go$$

with $Go = 32.0882 \frac{f}{s^2}$, a = 2.092587405E 7 ft

c. Zero velocity update complete indication in RGSS mode will be a function of P11.11 and P12.12. (X and Y accelerometer gravity deflection covariance elements) the complete value is TBD.

d. The Kalman has been modified to allow operator selectable smoothing with position update or no position update. The original mechanization would update the system state vector and associated matrices when a position update was performed. The Kalman position update function is now selectable during initial data entry, by cueing RAP C-E (Regional Adjustment Program, No-Yes). If RAP is selected, no Kalman update will be run when 'Update' is pressed, but observation error (Inertial-Control Point) will be algebraically subtracted from present inertial position and result will be used for all succeeding display, smoothing and recording outputs. The observation error will be accepted if: $(2.8 \text{ Sigma})^2$x Position Covariance + $(10 \text{ Meters})^2$ > $(\text{Error})^2$.

A second update attempt will be accepted if: $(4)^2$x$(2.8 \text{ Sigma})^2$x Position Covariance + $(10 \text{ Meters})^2$ > $(\text{Error})^2$.

2.9.2 <u>CDU Modifications</u>. For CDU modifications, see figure 4.

2.9.3 <u>Digit Display Mode</u>. If system is not in Prompting Mode (i.e., Flashing Sph,) or Entry Mode, a series of displays can be recalled by pressing digit keys 0 through 2.

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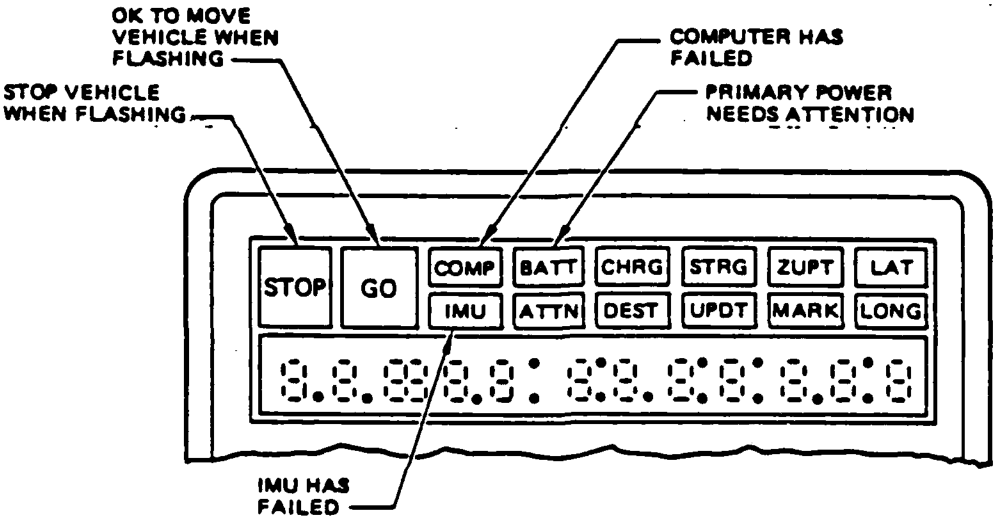
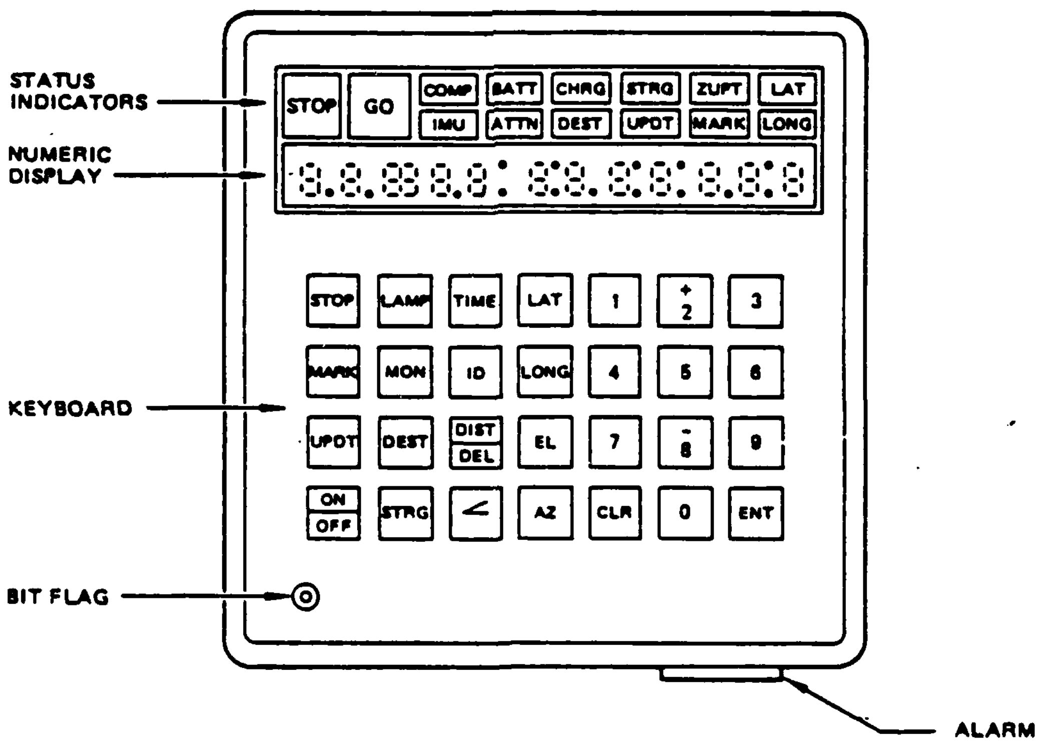


CDU STATUS INDICATORS



FRONT PANEL OF CDU

Figure 4. CDU Modifications

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Digit	Function	Display
0	Gravity Magnitude	GM xxxx.xx (mgal)
1	Gravity Deflection N-S	N/S xxx.xx GD (μg)
2	Gravity Deflection E-W	E/W xxx.xx GD (μg)

NOTES

1. If information is not available, dashes will be displayed.

2. This information is saved in PAE table and can be recalled by pressing digit 0 through 2 when PAE display is active.

2.9.4 Additional MON ID Displays

a. ID55 entered initial deflection N-S

b. ID56 entered initial deflection E-W

c. ID57 mission status display

NOTE

A=Air, M=Magnitude, D=Deflection, S=Total Station
R=Rap Mode

A M D S R 1 1 1 1 1

2.9.5 LASS-II Initial Prompting

Prompt	Function	Entries
S P H	Spheroid	2
LA	Latitude	+/-xx°xx'xx.xxx"
LO	Longitude	+/-xxx°xx'xx.xxx"
EL	Elevation	+/-xxxx.xx Meters
JN	Job Number	8

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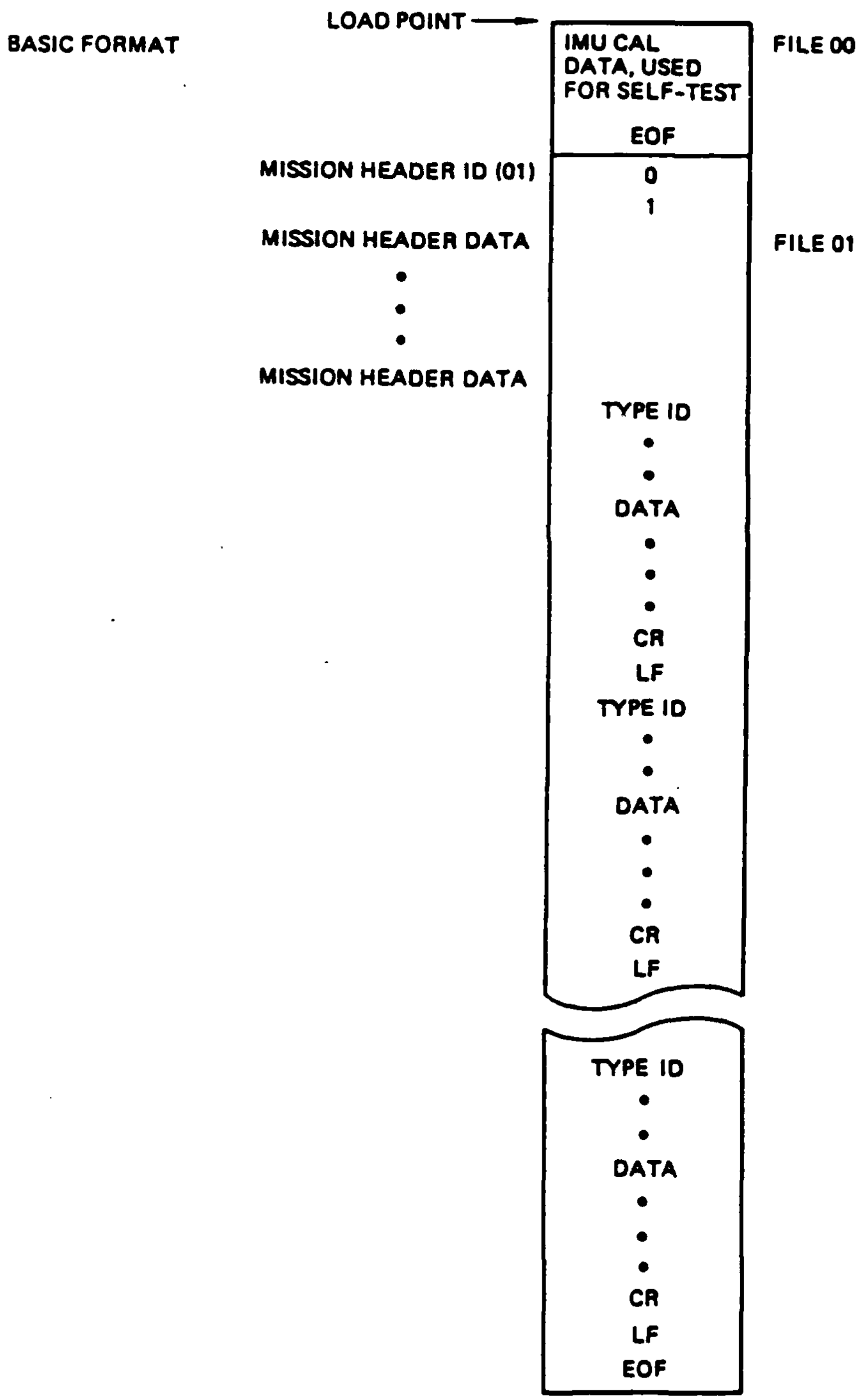
Prompt	Function	Entries	
D A T	Date	6	
O T	Time	6	
GRA C-E	Gravity Mission	C or E	
	If E Pressed	C Pressed	
ONO	Meter Number	7	
SFM	Scale Factor	6	
BG	Base Gravity	8	ALN
DEFC-E	Deflection Mission	C or E	
	If E pressed	C Pressed	
DN	Deflection North	+/-xx.xx arcsec	
DE	Deflection East	+/-xx.xx arcsec	
TS C-E	Total Station	C or E	
ALN	Align Time	xx Minutes (60 max)	
RAP C-E	RAP Mission	C or E	
Air C-E	Hover Zupt	C or E	
MON 0	End of Prompting		

2.9.6 Compensation Tables. x, y and z accelerometers and gyros are compensated for turnaround effects. Accelerometer bias and gyro drift changes will be measured only 22.5 degrees, and a table will be constructed containing six variables (3 accelerometers and 3 gyros). Compensation will be applied (Modulo 22.5 degrees) with linear interpolation between 22.5 degree increments.

2.9.7 Expansion of Mark Table. Length of Mark (PAE) table has been increased from 26 words to 34 words for Regional Adjustment Program Requirements. Also number of Mark records has been increased from 30 to 50 records.

2.9.8 LASS-II Tape Formats

2.9.8.1 Basic Format



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2.9.8.2 Type ID

01 = Mission Header Record

02 = ZUPT Record

03 = Mark/Update Record

04 = Spare

05 = Meander Record

06 = Waypoint Record

2.9.8.3 Record Formats

4516 word is stored B0-7 in first byte, then B8-15 in next byte.

Example: GVN:(0 1 2 . . . 27 28 29 30 31)

Tape	B0-7	1st byte
	B8-15	2nd byte
	B16-23	3rd byte
	B24-31	4th byte

a. Each record begins with 2 byte 'type ID'.

b. Each record ends with CR LF

c. Track zero is selected with all mission data in file 01.

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2.9.9 Records

2.9.9.1 Mission Header Record (01)

WORD LENGTH	NAME	SCALAR	DESCRIPTION/VALUE
1	RMISSID		'01'
2	DPRJNUM		PROJECT NUMBER
2	DDATE		DATE
2	DTIMEM		TIME
1	DSPHEROID		SPHEROID
2	DAIRGND		AIR OF GROUND
2	DGRAV		GRAVITY FLG
2	DDEF		-1 = DEF. MODE
2	DTOTSA		-1=TOTAL STATION
2	DRAPFG		-1 = RAP MODE
2	DDEFN	.01AS, B31	ENTERED DEFLECT. N
2	DDEFE	.01AS, B31	ENTERED DEFLECT. E
2	DMTRNO		METER NUMBER
2	DMTRSF		METER SCALE FACTOR
2	DBASGRA		BASE GRAVITY
2	DALNTYP		ALIGN TIME
1	BFMAL1+0		MAL WORDS
1	BFMAL1+1		MAL WORDS
1	+2		MAL WORDS
1	+3		MAL WORDS
1	+4		MAL WORDS
1	+5		MAL WORDS
1	+6		MAL WORDS
1	+7		MAL WORDS
1	BFMAL1+8		MAL WORDS
1	+9		MAL WORDS
1	+10		MAL WORDS
1	DLXPB	FB6	DOOR/SKID SIGHT
1	DLYPB	FB6	
1	DLZPB	FB6	

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WORD LENGTH	NAME	SCALAR	DESCRIPTION/VALUE
1	DLXPP	FB6	PORROPRISM
1	DLYPP	FB6	
1	DLZPP	FB6	
1	DLXSK	FB6	PROTRACTOR
1	DLYSK	FB6	
1	DLZSK	FB6	
2	GPHI	SC, BO	LATITUDE
2	GLAMBDA	SC, BO	LONGITUDE
2	GH	FB16	ELEVATION
2	GMALF		MAL WORDS
2	NGBAX	R/S, B-12	ALN. BIAS X-GYRO
2	NGBAY	R/S, B-12	ALN. BIAS Y-GYRO
2	NABAZ	F/S^2, B-12	Z-ACCEL. BIAS
2	GBLZ	R/S, B-12	Z-GYRO BIAS
2	DAZALN	SC,BO	INSTALLATION ANGLE
1	RCRLF	-	CR, LF
= 69			

2.9.9.2 ZUPT Record (02)

WORD LENGTH	NAME	SCALAR	VALUE
1	RZPTID		'02'
2	RLONSUM	SCBO	SUMMATION KALMAN CORRECTIONS
2	RLATSUM	SCBO	SUMMATION KALMAN CORRECTIONS
2	RELSUM	FB16	SUMMATION KALMAN CORRECTIONS
1	BFMAL1+0		MAL WORDS
1	BFMAL1+1		MAL WORDS
1	+2		MAL WORDS
1	+3		MAL WORDS
1	+4		MAL WORDS
1	+5		MAL WORDS

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WORD LENGTH	NAME	SCALAR	VALUE
1	+6		MAL WORDS
1	+7		MAL WORDS
1	+8		MAL WORDS
1	+9		MAL WORDS
1	+10		MAL WORDS
2	RVXSUM	F/S B9	SUMMATION KALMAN CORRECTIONS
2	RVYSUM	F/S B9	SUMMATION KALMAN CORRECTIONS
2	RVZSUM	F/S B9	SUMMATION KALMAN CORRECTIONS
1	KTTV	SB15	VERTICAL TRAVEL TIME
1	KTTH	SB15	HORIZONTAL TRAVEL TIME
2	DAIRFG	AIR/GND. FLAG	-1 = AIR
1	RLASVAL	LASER VALID FLAG	-1 = VALID
3	KIDE	F*S (FP)	"D" COEFFICIENT
3	KIDN	F*S (FP)	"C" COEFFICIENT
2	GPHI	SCBO	LATITUDE
2	GLAMBDA	SCBO	LONGITUDE
2	GH	FB16	ELEVATION
2	GPSIP	SCBO	PLATFORM HEADING
2	SPARE		NOT USED
2	RXDSUM	F/S^2BO	SUM KALMAN
2	RYDSUM	F/S^2BO	CORRECTIONS FOR
2	RZASUM	F/S^2BO	DEFLECTION
2	RXTSUM	RB-4	SUM KALMAN TILT
2	RYTSUM	RB-4	CORRECTIONS
2	RZTSUM	SCBO	CORRECTIONS
2	GTIME	64_{us}, B31	TIME
1	DTMINZP	SB15	TIME IN THIS ZUPT
1	RCRLF		CR, LF
= 62			

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2.10.9.3 Mark/Update Record (03)

WORD LENGTH	NAME	SCALAR	DESCRIPTION/VALUE
1	RMRUPID		'03'
1	DMKTAB+0		PAE ACCT
1	+1		SYSTEM TIME
2	+2	SB15	LATITUDE
2	+4	SCBO	LONGITUDE
2	+6	FB16	ELEVATION
2	+8	SCBO	HORZ. ANGLE
2	+10	SCBO	TRUE AZIMUTH
2	+12	.01M, B15	DIST
1	+14	SB15	VERT. TRAVEL TIME
1	+15	SB15	HORZ. TRAVEL TIME
3	+16	DIDE	D FLOATING POINT
3	+19	DIDN	C FLOATING POINT
2	+22	.01M, B15	VERTICAL DIST.
2	+24	B31	MARK ID
2	+26	SCBO	ZENITH ANGLE
2	-NABGZ+28	F/S^2BO	GRAVITY MAGNITUDE
2	-NABGY+30	F/S^2BO	NORTH DEFLECT.
2	-NABGX+32	F/S^2BO	EAST DEFLECT.
2	DGRAVNOM	.01 MILL16A6.831	ENTERED GRAVITY MAGNITUDE
1	NPITP	SCBO	PITCH
1	NROLP	SCBO	ROLL
1	RLEVFG		LEVER ARM SELECT
2	NDISTVL	FB27	DIST. TRAVELLED
2	RLATRAW	SCBO	OLD LATITUDE
2	RLONRAW	SCBO	OLD LONGITUDE
2	RAZRAW	SCBO	OLD AZIMUTH
2	RELRAW	FB16	OLD ELEVATION
1	RCRLF		'CR, LF
= 50			

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2.10.9.4 Meander Record (05)

Word LENGTH	NAME	SCALAR	DESCRIPTION/VALUE
1	RMEAND		'05'
1	RMEANID		LAST MARK ID
2	GTIME	64_{us}, B31	TIME
2	GPHI	SCBO	LATITUDE
2	GLAMBDA	SCBO	LONGITUDE
2	GH	FB16	ALTITUDE
1	NPITP	SCBO	PITCH
1	NROLP	SCBO	ROLL
1	GPSIP+1	SCBO	AZIMUTH
2	DTVLDIS	.1M, B31	TRAVEL DISTANCE
2	RGNDEL	FB16	LASER GRND ELEV.
2	RLASRNG	FB16	LASER RANGE
1	RLASVAL		-1 = LASER DATA VALID
1	KTTV	SB15	VERT. TRAVEL TIME
1	KTTH	SB15	HORZ. TRAVEL TIME
1	RSTWD		RECORDER STATUS
1	RCRLF		CR, LF
= 24			

2.10.9.5 Waypoint Record (06)

WORD LENGTH	NAME	SCALAR	VALUE
1	06		ID
400	DDESTCAT		DESTINATION CATALOG
1	RCRLF		CR, LF
= 402			

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FSCM 06481

APPENDIX A

SECOND INTERIM TECHNICAL REPORT

FOR

RGSS PROGRAM

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FSCM 06481

APPENDIX A

This appendix contains design file memos and changes (ECN's) to the RGSS hardware, to reflect the current mechanical and electrical configuration. Specific build and fabrication information was accomplished under demonstration ground rules, hence was verbal in nature. Documentation was upgraded by internal policy to higher quality prints in lieu of demonstration prints which are redlined documentation only. The Family tree, therefore, provides all of the build information required to reproduce the existing design.

Enclosures:

Family Tree
LASS 11:85:16.3/8
LASS 11:85:16.2/2
LASS 11:85:16.2/3
LASS 11:85:16.2/4

PL 867941
LASS 16.3/10
16.3/5
16.3/6
16.4/5
LASS II 16.8/1
16.8/1A
16.8/1B
Level Axis Schematic, Accel
ECN 143847
143848
RGSS 16.4/4
16.4/4A
16.4/4B
5.15/1
ECN 143843
RGSS 16.0/3
16.0/4
ECN 143844
ECN 143852

469440A

COPIES TO:

Litton Guidance & Control Systems

OFFICE CORRESPONDENCE

FILE: LASS II 16.2/2

DATE: 23 April 1985

SUBJECT: RGSS STABLE ELEMENT WIRING MODIFICATION

TO:	Design File	LOC.:		EXT.:	
FROM:	J. Welch	LOC.	76/37	EXT.:	3587

Attached are instructions to remove unused wired and the addition of new wires to the stable element required for the A1000 accelerometers in the level axes.

J. Welch

JW:jd

Attachment: Project Office only

INSTRUCTIONS TO MODIFY PADS IMU TO LASS II (RGSS) CONFIGURATION. REFERENCE WIRING DIAGRAM 880970, AI WIRE LIST 880970-1-350 AND 880970-1-400

REMOVE THE FOLLOWING WIRES FROM THE STABLE ELEMENT HARNESS.

FROM	TO		AI-400	AI-350
A5-1	A12-4	TG		28
A5-6	A12-6	TG		28
A6-2	J24-H			14, 17
A5-2	J24-H	TG	21	14, 17
J18-L	J24-F	TG	21	14, 17
A1-8	J24-F	TG		14, 17
J18-J	A5-2	TG	21	
J26-G	A5-3		26	29
J26-G	P20-5		26	
A5-3	P22-3			10
A5-4	J26-J	TG		22, 23
A5-5	J26-E	TG		22, 23
A12-5	J26-J			22, 23
A5-4	A7-7			27
A5-9	A6-9	TG	18	
A5-10	A6-10	TG	18	
A5-10	J18-T	TG	30	30
A5-9	J18-V	TG	31	30
J26-S	J26-K		14	
J26-D	J26-U		14	
J26-H	P21-8	TG	26	9
J26-F	P21-14	TG	26	9
J26-H	J18-X	TG	26	29
J26-F	J18-W	TG	26	29
J24-L	J26-L		26, 41B	
J24-L	J17-F		29, 41B	
J24-G	E9			15, 17
J24-G	A6-3			15, 17
J24-E	A6-5	TG		14, 17
J24-J	A6-4	TG		14, 17
J26-B	A6-1		26	29

ATTACH THE FOLLOWING LOOSE WIRES WHICH ARE TAGGED TO THE FOLLOWING. TRIM AS REQUIRED. IF WIRE IS TOO SHORT, REPLACE FULL RUN.

FROM	TO (TAGGED)		CONNECT TO	SIG		
A4-1	A5-6	TG	A12-6	+15VDC		
A4-6	A5-1		A12-4	-15VDC		
J18-U	A5-4		A12-5	GND		
P22-S	A6-3		A100-(H)	L.G. S.A. MU	(REPLACES A6)	A6-8
A1-2	A6-1	TG	A100-(C)	-15VDC		A6-3
A1-5	A6-6		A100-(D)	+15VDC		A6-4
A2-2	A6-6	TG	A100-(D)	+15VDC		A6-4
A2-6	A6-1		A100-(C)	-15VDC		A6-3
A3-8	A6-6		A100-(D)	+15VDC		A6-6

ADD THE FOLLOWING WIRES FROM POINT TO POINT. ROUTE WITH THE SHORTEST RUN.

FROM	TO		SIG	(TO)
J24-R	A100-(C)		-15VDC	A6-3
J24-J	A7-8	TG	GND	
J24-K	A7-9		54KHZ	
J24-L	A100-(B)		ACCEL S.F. RTN	A6-2
J24-D	A100-(E)		A_Y	A6-6
J24-U	A12-6		+15VDC	
J26-J	A7-7	TG	GND	
J26-K	A7-9		54KHZ	
J26-U	A12-6	TG	+15VDC	
J26-R	A12-4		-15VDC	
J26-L	A100-(A)		ACCEL S.F. RTN.	A6-1
J26-D	A100-(E)		A_X	A6-5
J18-L	A1-8		IN ϕ 7.5VAC 4.8KHZ	
J18-W	P21-14	TG	IN ϕ 7.5VAC 4.8KHZ	
J18-X	P21-8		QA ϕ 7.5VAC 4.8KHZ	
J17-F	A100-(B)		ACCEL S.F. RTN	A6-7
P22-3	A100-(G)		LG N.A. MU	A6-7
P20-S	A100-(G)		UG. S.A. MU	A6-7
E9	A100-(H)		UG. N.A. MU	A6-8

ATTACH THE FOLLOWING LOOSE WIRES WHICH ARE TAGGED TO THE FOLLOWING. TRIM AS REQUIRED. IF WIRE IS TOO SHORT, REPLACE FULL RUN.

FROM	TO (TAGGED)		CONNECT TO	SIG	
A4-1	A5-6	TG	A12-6	+15VDC	
A4-6	A5-1	TG	A12-4	-15VDC	
J18-U	A5-4		A12-5	GND	
P22-S	A6-3		A100-(H)	L.G. S.A. MU	(REPLACES A6)
A1-2	A6-1	TG	A100-(C)	-15VDC	
A1-5	A6-6	TG	A100-(D)	+15VDC	
A2-2	A6-6	TG	A100-(D)	+15VDC	
A2-6	A6-1	TG	A100-(C)	-15VDC	
A3-8	A6-6		A100-(D)	+15VDC	

ADD THE FOLLOWING WIRES FROM POINT TO POINT. ROUTE WITH THE SHORTEST RUN.

FROM	TO		SIG
J24-R	A100-(C)		-15VDC
J24-J	A7-8	TG	GND
J24-K	A7-9	TG	54KHZ
J24-L	A100-(E)		ACCEL SF RTN
J24-D	A100-(F)		AY
J24-U	A12-6		+15VDC
J26-J	A7-7	TG	GND
J26-K	A7-9	TG	54KHZ
J26-U	A12-6	TG	+15VDC
J26-R	A12-4	TG	-15VDC
J26-L	A100-(A)		ACCEL S.F. RTN.
J26-D	A100-(E)		AX
J18-L	A1-8		IN ϕ 7.5VAC 4.8KHZ
J18-W	P21-14	TG.	IN ϕ 7.5VAC 4.8KHZ
J18-X	P21-8	TG.	OUT ϕ 7.5VAC 4.8KHZ
J17-F	A100-(B)		ACCEL S.F RTN
P22-3	A100-(G)		LG H.A. MU
P20-5	A100-(G)		UG. S.A. MU
E9	A100-(H)		UG. H.A. MU

			-400	-350
J24-K	TO	J24-S	12	15, 18
J24-D		J24-U	12	14, 16
A6-4		A7-8	19	28

REMOVE THE FOLLOWING WIRES FROM TERMINATIONS AT ONE END ONLY. TAG FOR FUTURE USE

FROM	TO		LIFT WIRE AT	
A5-6	A4-1	TG	A5-6	27
A5-1	A4-6		A5-1	27
A5-4	J18-U		A5-4	30
P22-5	A6-3		A6-3	10
A1-2	A6-1	TG	A6-1	28
A1-5	A6-6		A6-6	28
A2-2	A6-6	TG	A6-6	28
A2-6	A6-1		A6-1	28
A3-8	A6-6		A6-6	28

469440A

Litton Guidance & Control Systems

COPIES TO: S. Bishop
J. Eckenrode
G. Janson
66 T. Neales

OFFICE CORRESPONDENCE

FILE: LASS II 16.2/3

DATE: 14 January 1986

SUBJECT: RGSS STABLE ELEMENT WIRING MODIFICATION

TO: Design File LOC: EXT:

FROM: J. Welch LOC 76/37 EXT: 3587

Add the following information to DFM 16.2/2. Add wire from A7-1 to A12-5. Signal is ground.

J. Welch

JW:jd

469440A

Litton Guidance & Control Systems

COPIES TO: Attached

OFFICE CORRESPONDENCE

FILE: LASS II 16.2/4

DATE: 10 March 1986

SUBJECT: RGSS STABLE ELEMENT WIRING MODIFICATION

TO: Design File LOC.: EXT.:

FROM: J. Welch LOC. 76/37 EXT.: 3587

Add the following information to DFM 16.2/2

Remove wires from J24-L to A6-2
J26-L to A6-2

Add wires from J24-L to J18-V
J26-L to J18-T

Reason: Isolation of accelerometer scale factor returns to quantizer. Reference ECN (Electrical Change Notice) 143849 and 143850 (attached).

J. Welch

JW:jd

GUIDANCE & CONTROL SYSTEMS

469440A

ELECTRICAL CHANGE NOTICE

ECN № 143849

SCHEMATIC 867941

PROJECT	UNIT	MODULE	ASSEMBLY TO BE CHANGED	SHEET
RGSS	IMU	S.E. Sub Assy	867941	1 OF 1

REASON FOR CHANGE

ACCELEROMETER SCALE FACTOR RETURN ISOLATION REQUIRED

DRAWINGS AFFECTED	SYSTEM YES	SYSTEM NO	UNIT YES	UNIT NO	MODULE YES	MODULE NO
SCHEMATIC CHANGE	☐	☒	☒	☐	☒	☐
ES/ATS CHANGE	☐	☒	☐	☒	☐	☒
TEST EQUIP CHANGE	☐	☒	☐	☒	☐	☒
ABM CHANGE	☐	☒	☐	☒	☐	☒

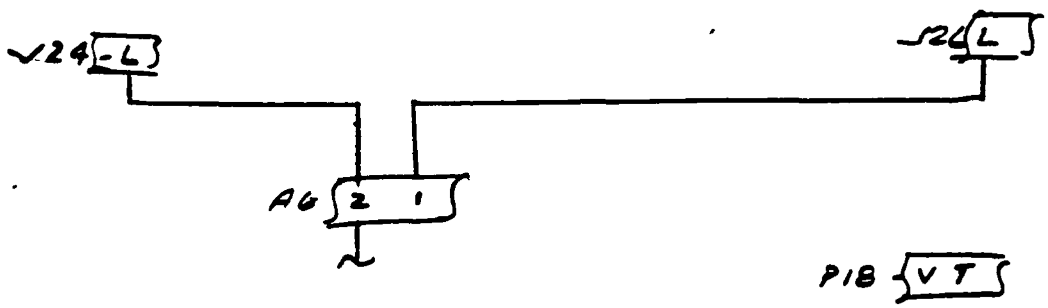
DRAWINGS AFFECTED	SYSTEM YES	SYSTEM NO	UNIT YES	UNIT NO	MODULE YES	MODULE NO
ARTWORK CHANGE	☐	☒	☐	☒	☐	☒
ASSEMBLY DWG CHANGE	☐	☒	☐	☒	☐	☒
WIRE LIST CHANGE	☐	☒	☒	☐	☒	☐

DESCRIPTION OF CHANGE:

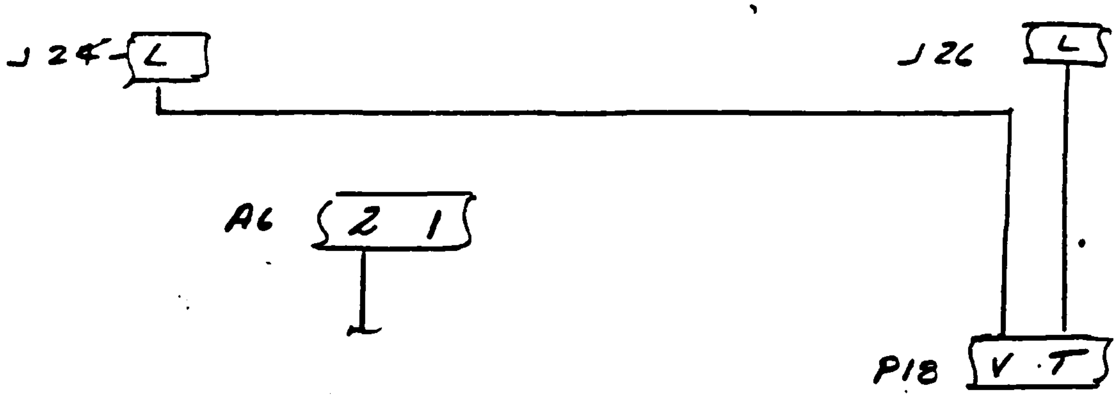
ASSY 867941 SHT 1

CHANGE NOTE $\boxed{7}$ TO ADD: MODIFY WIRING PER CLASS II DFM 16.2/2

SHT 2 FROM:



TO:



PREPARED BY	DATE	SYSTEMS ENGINEER	DATE	DEPT MANAGER	DATE
WELCH	10 MAR 86	[signature]	10 MAR 86		
PROJECT OFFICE	DATE	MECH ENGRNG ACCEPTANCE		DATE	

FORM 28-483 (R6-74)

GUIDANCE & CONTROL SYSTEMS

469440A

ELECTRICAL CHANGE NOTICE

ECN № 143850

SCHEMATIC: 867940

PROJECT	UNIT	MODULE	ASSEMBLY TO BE CHANGED	SHEET
RGSS	IMU	S.E. SUBASSY		1 OF

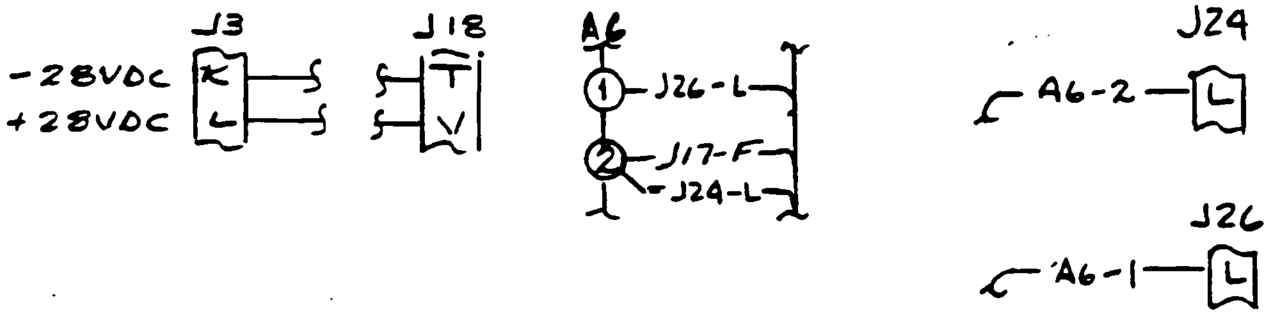
REASON FOR CHANGE: ACCELEROMETER SCALE FACTOR RTN ISOLATION REQ'D.

DRAWINGS AFFECTED	SYSTEM YES	SYSTEM NO	UNIT YES	UNIT NO	MODULE YES	MODULE NO
SCHEMATIC CHANGE	☐	☐	☐	☐	☐	☐
ES/ATS CHANGE	☐	☐	☐	☐	☐	☐
TEST EQUIP CHANGE	☐	☐	☐	☐	☐	☐
ABM CHANGE	☐	☐	☐	☐	☐	☐

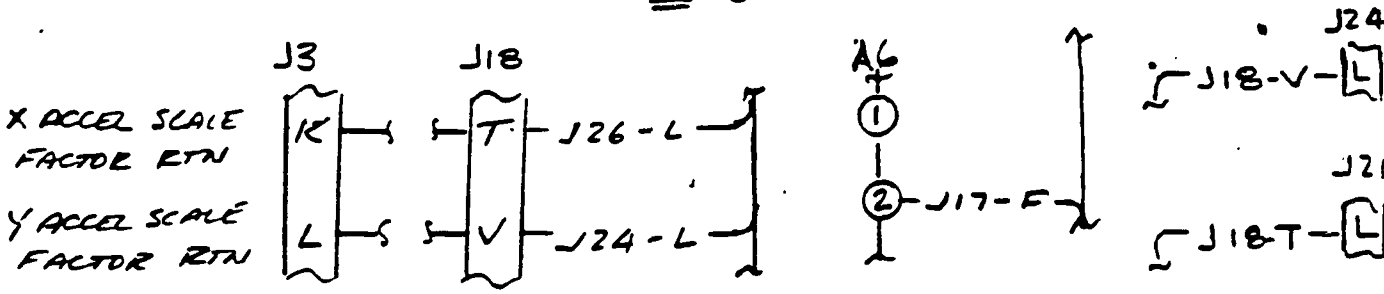
DRAWINGS AFFECTED	SYSTEM YES	SYSTEM NO	UNIT YES	UNIT NO	MODULE YES	MODULE NO
ARTWORK CHANGE	☐	☐	☐	☐	☐	☐
ASSEMBLY DWG CHANGE	☐	☐	☐	☐	☐	☐
WIRE LIST CHANGE	☐	☐	☐	☐	☐	☐

DESCRIPTION OF CHANGE:

SCHEMATIC 867940 CHANGE FROM:



TO:



PREPARED BY	DATE	SYSTEMS ENGINEER	DATE	DEPT MANAGER	DATE
WELCH	3-10-86	[signature]	10 MAR 86		

PROJECT OFFICE	DATE	MECH ENGRNG ACCEPTANCE	DATE

FORM 28-483 (R6-74)

GUIDANCE & CONTROL SYSTEMS

469440A

ELECTRICAL CHANGE NOTICE

ECN Nº 143845

SCHEMATIC 867940 & 867941

PROJECT	UNIT	MODULE	ASSEMBLY TO BE CHANGED	SHEET
RGSS	IMU	S. E.	N. A.	1 OF 1

REASON FOR CHANGE

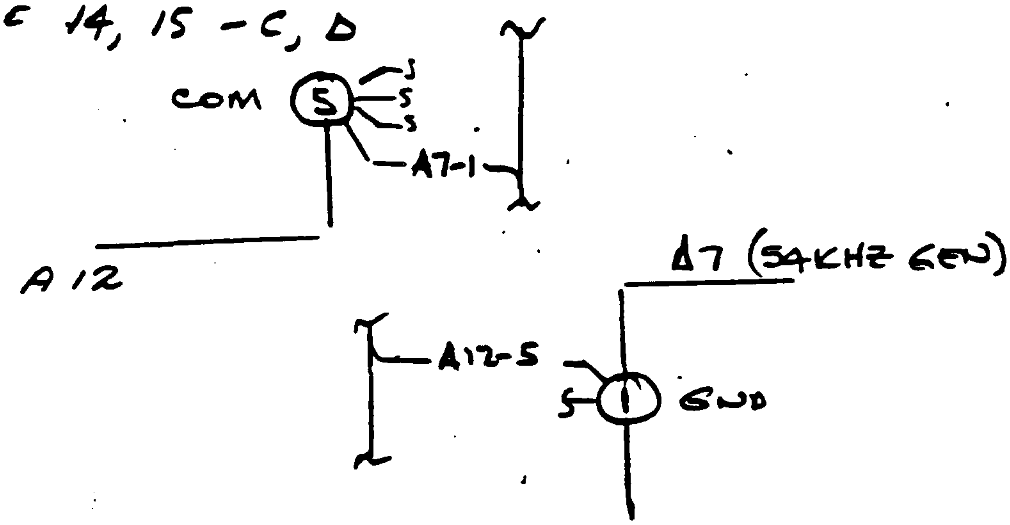
GROUND WIRE REQUIRED

DRAWINGS AFFECTED	SYSTEM YES	SYSTEM NO	UNIT YES	UNIT NO	MODULE YES	MODULE NO
SCHEMATIC CHANGE	☐	☒	☐	☒	☒	☐
ES/ATS CHANGE	☐	☒	☐	☒	☐	☒
TEST EQUIP CHANGE	☐	☒	☐	☒	☐	☒
ABM CHANGE	☐	☒	☐	☒	☐	☒
ARTWORK CHANGE	☐	☒	☐	☒	☐	☒
ASSEMBLY DWG CHANGE	☐	☒	☐	☒	☐	☒
WIRE LIST CHANGE	☐	☒	☐	☒	☐	☒

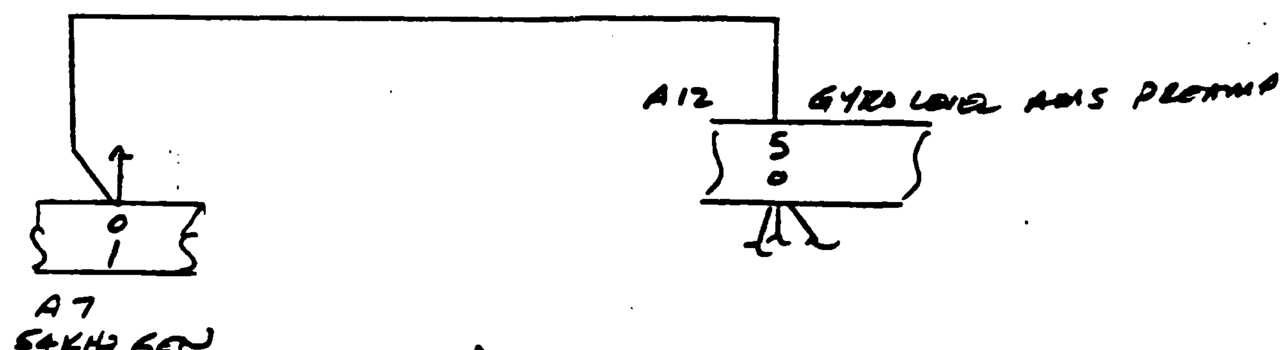
DESCRIPTION OF CHANGE:

SCHEMATIC 867940 - CHANGE TO:

ZONE 14, 15 - C, D



DWG 867941 CHANGE TO:



PREPARED BY	DATE	SYSTEMS ENGINEER	DATE	DEPT MANAGER	DATE
WELCH	1.14.86	[signature]	1.14.86		

PROJECT OFFICE	DATE	MECH ENGRNG ACCEPTANCE	DATE

FORM 28-483 (R6-74)

COPIES TO:

Litton Guidance & Control Systems

OFFICE CORRESPONDENCE

FILE: LASS II:85:16.3/8

DATE: 29 April 1985

SUBJECT: Miscellaneous RGSS Prints

TO: DESIGN FILE LOC: EXT.:

FROM: J. Welch LOC. 76/37 EXT. 3587

Stable Element Assembly Drawing 880965 and Parts List has been marked to RGSS configuration. New drawing number is 867943. Marked up copy to Project Office only.

J. Welch

JW:rf

Attachment

469440A

COPIES TO:

Litton Guidance & Control Systems

FILE: LASS II 16.3/5 **OFFICE CORRESPONDENCE**

DATE. 19 April 1985

SUBJECT: MISCELLANEOUS RGSS DRAWINGS

TO: Distribution LOC.: EXT.:

FROM: J. Welch LOC 76/37 EXT.: 3587

Functional block diagram, inertial measurement unit has been marked to the RGSS configuration. Old drawing - 880903 - New drawing 864419.

J. Welch

JW:jd

Attachment - Project Office only

469440A

COPIES TO:

Litton Guidance & Control Systems

OFFICE CORRESPONDENCE

FILE: LASS 16.3/6

DATE. 23 April 1985

SUBJECT: MISCELLANEOUS RGSS DRAWINGS

TO: Design File LOC.: EXT.:

FROM: J. Welch LOC. 76/37 EXT.: 3587

Schematic diagram electronic gimbal assembly has been marked to the RGSS configuration. Old drawing 880962; New drawing number 867940.

Stable Element Sub Assembly has been marked to the RGSS configuration. Old drawing 880970. New drawing number 867941. The Parts List has also been marked to reflect the RGSS configuration.

Copies (originals) to the Project Office only.

J. Welch

JW:jd

COPIES TO:

Guidance & Control Systems

OFFICE CORRESPONDENCE

FILE: LASS II 16.4/5

DATE. 23 April 1985

SUBJECT: ACCELEROMETER LEVEL AXES - RGSS

TO: Design File LOC.: EXT.:

FROM: J. Welch LOC. 76/37 EXT.: 3587

Attached to the Project Office/design file are red lined and original drawings for distribution for Data Control.

Title	Old Dwg.No.	New Dwg.No.
Accelerometer Assy. Level Axis	N.A.	864412
Accelerometer Assy. Vertical Parts List	PL880990	PL864412
Accelerometer Wiring Wiring Diagram	880992	864415
Accelerometer Housing Outer	N.A.	864413
Accelerometer Housing Inner	N.A.	864414

J. Welch

JW:jd

469440A

COPIES TO:

Litton Guidance & Control Systems

OFFICE CORRESPONDENCE

FILE: LASS II 16.8/1B
16.3/7

DATE. 23 April 1985

SUBJECT: MASS UNBALANCE COMPENSATION AMPLIFIER

TO: Design File   LOC.:   EXT.:

FROM: J. Welch   LOC. 76/37   EXT.: 3587

To facilitate the drawing package the following pin out for the Mu Comp Ampl shall be used.

Pin	Signal
1	X Accel Gnd
2	Y Accel Gnd
3	-15VDC
4	+15VDC
5	X Accel Input
6	Y Accel Input
7	U.G. Comp SA/ and LG Comp HA/VA
8	U.G. Comp HA/VA and LG Comp SA

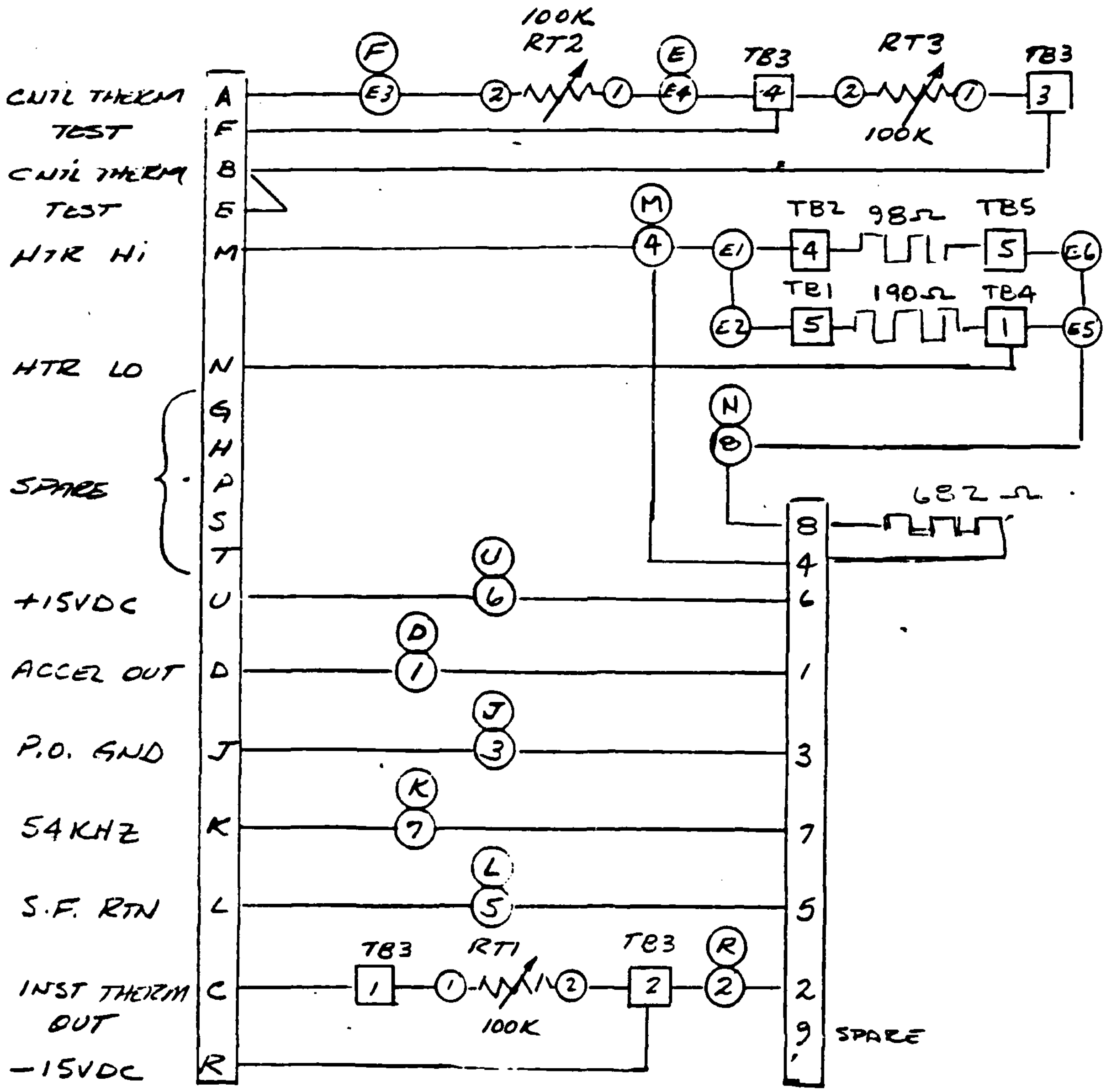
The assembly and schematic number are 867942.

J. Welch

JW:jd

Litton GUIDANCE & CONTROL SYSTEMS
5500 Canoga Avenue, Woodland Hills, California 91365

FSCM 06481



GENERATED BY-
ECN K43847

Δ-1000 ACCEL

SCHEMATIC RGSS
LEVEL AXIS ACCELS
3.7.86

GUIDANCE & CONTROL SYSTEMS

469440A

ELECTRICAL CHANGE NOTICE

ECN № 143847

SCHEMATIC: WD 864415

PROJECT	UNIT	MODULE	ASSEMBLY TO BE CHANGED	SHEET
RGSS	IMU	ACCEL	864412	1 OF 1

REASON FOR CHANGE: ADDITIONAL CLEARANCE REQUIRED

DRAWINGS AFFECTED	SYSTEM YES	SYSTEM NO	UNIT YES	UNIT NO	MODULE YES	MODULE NO
SCHEMATIC CHANGE	☐	☐	☐	☐	☒	☐
ES/ATS CHANGE	☐	☐	☐	☐	☐	☒
TEST EQUIP CHANGE	☐	☐	☐	☐	☐	☒
ABM CHANGE	☐	☐	☐	☐	☐	☒
ARTWORK CHANGE	☐	☒	☐	☒	☐	☒
ASSEMBLY DWG CHANGE	☐	☒	☐	☒	☒	☐
WIRE LIST CHANGE	☐	☒	☐	☒	☒	☐

DESCRIPTION OF CHANGE:

WIRING DIAGRAM 864415

CHANGE FROM: TO:

FROM	TO	TO
P1-A	FP1-F	FP1-E3
D	FP1-D	FD1-1
E	SPARE	P1-B
F	SPARE	TB3-4
J	FP1-J	FP1-3
K	FP1-K	FP1-7
L	FP1-L	FP1-5
M	FP1-M	FP1-4
N	FP1-N	TB4-1
R	FP1-R	TB3-2
P1-U	FP1-U	FP1-6
TB3-2	FP1-R	FP1-2
TB3-4	FP1-E	FP1-E4

CHANGE: TB5-3 TO FP1-E6 TO: TB5-5 to FP1-E6

PREPARED BY	DATE	SYSTEMS ENGINEER	DATE	DEPT MANAGER	DATE
WELCH	3.7.86	[signature]	3.7.86		

PROJECT OFFICE	DATE	MECH ENGRNG ACCEPTANCE	DATE

FORM 28-483 (R6-74)

GUIDANCE & CONTROL SYSTEMS

469440A

ELECTRICAL CHANGE NOTICE

ECN № 143848

SCHEMATIC N.A.

PROJECT	UNIT	MODULE	ASSEMBLY TO BE CHANGED	SHEET
RGSS	IMU	ACCEL	864412	1 OF 2

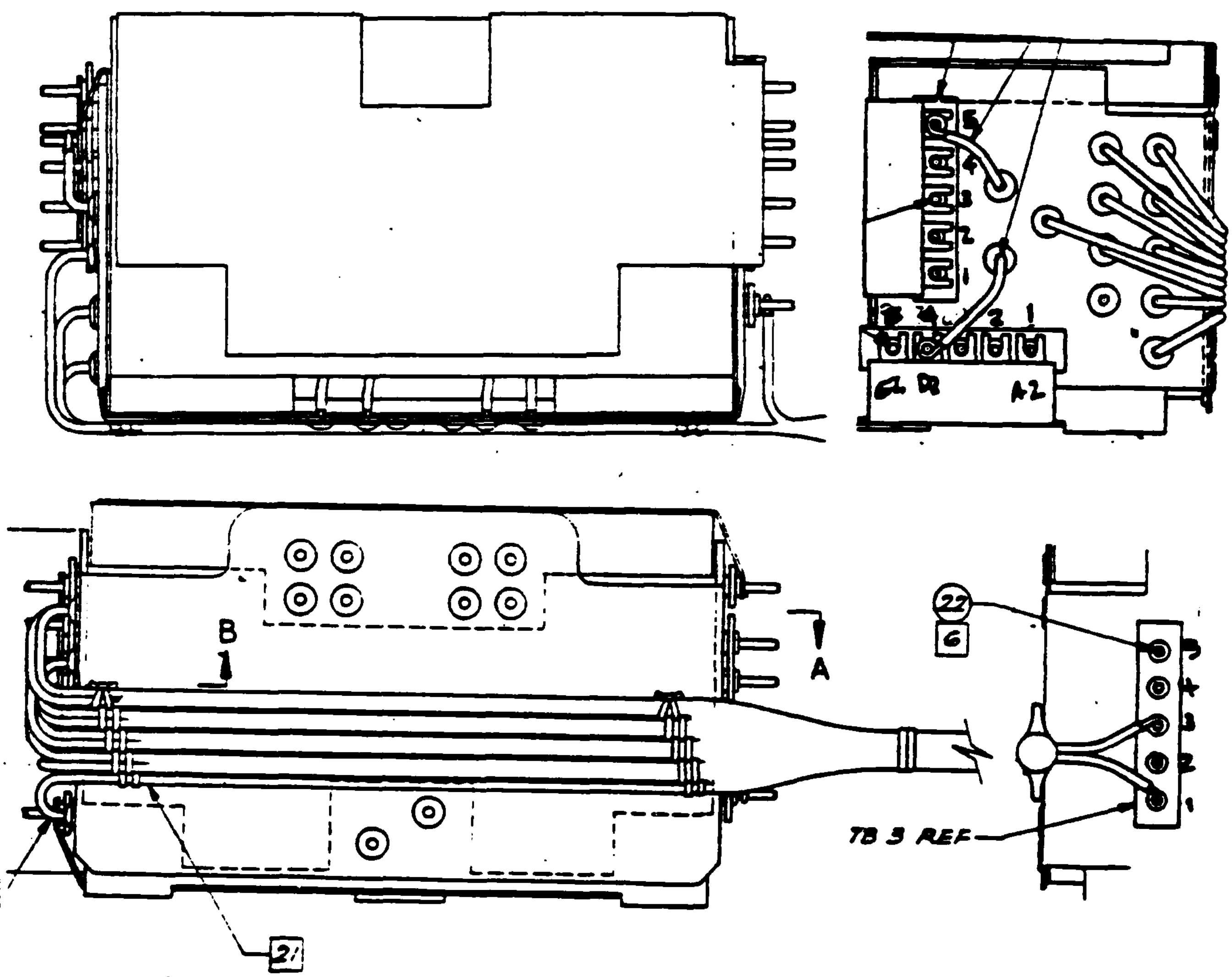
REASON FOR CHANGE

ADDITIONAL CLEARANCE REQUIRED

DRAWINGS AFFECTED	SYSTEM YES	SYSTEM NO	UNIT YES	UNIT NO	MODULE YES	MODULE NO	DRAWINGS AFFECTED	SYSTEM YES	SYSTEM NO	UNIT YES	UNIT NO	MODULE YES	MODULE NO
SCHEMATIC CHANGE	☐	☐	☐	☐	☐	☐	ARTWORK CHANGE	☐	☐	☐	☐	☐	☐
ES/ATS CHANGE	☐	☐	☐	☐	☐	☐	ASSEMBLY DWG CHANGE	☐	☐	☐	☐	☐	☐
TEST EQUIP CHANGE	☐	☐	☐	☐	☐	☐							
ABM CHANGE	☐	☐	☐	☐	☐	☐	WIRE LIST CHANGE	☐	☐	☐	☐	☐	☐

DESCRIPTION OF CHANGE:

ASSY 864412 CHANGE FROM:



PREPARED BY	DATE	SYSTEMS ENGINEER	DATE	DEPT MANAGER	DATE
Wittell	3.7.86	[signature]	3.7.86		

PROJECT OFFICE	DATE	MECH ENGRNG ACCEPTANCE	DATE

FORM 28-483 (R6-74)

GUIDANCE & CONTROL SYSTEMS

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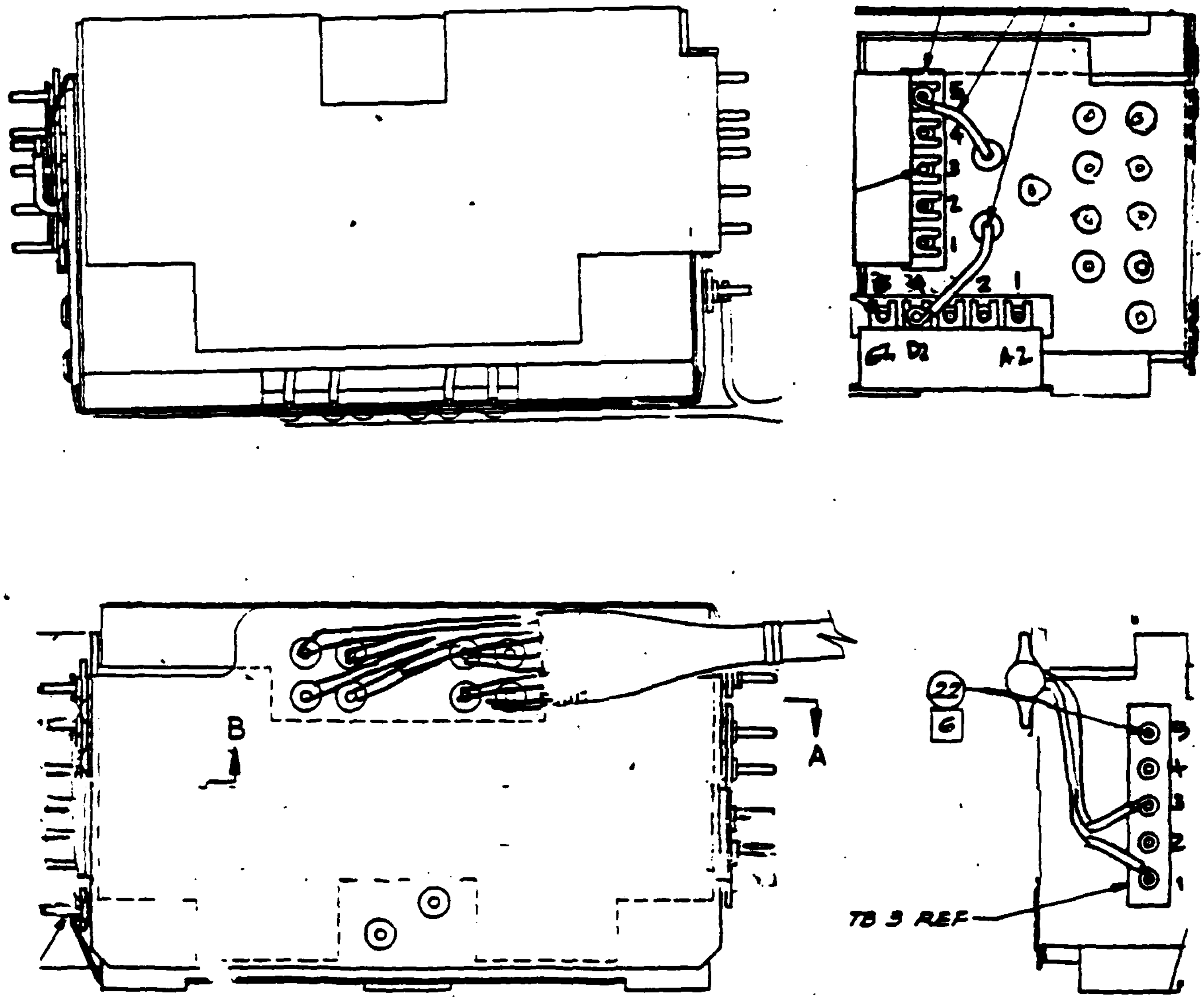
ECN No. 143848

Sheet 2 of 2

ELECTRICAL CHANGE NOTICE

DESCRIPTION OF CHANGE: (Continued)



DELETE NOTE $\boxed{21}$ AND REFERENCE TO SAME

Form 28-484 (R7-74)

469440A

Litton Guidance & Control Systems

OFFICE CORRESPONDENCE

COPIES TO:
J. Eckenrode
R. Fuller
G. Stevens
R. Toler
W. Weber
W. Waterhouse

FILE: RGSS 16.0/3

DATE: 7 December 1984

SUBJECT: QUANTIZER MODIFICATIONS FOR CHANGE OF LEVEL AXES ACCELEROMETERS

TO: Lass Design LOC: EXT:

FROM: J. Welch LOC: 76/37 EXT: 3587

Changes to Quantizer assembly 880945 shall be made under "Demo Systems" ground rules, which include red lined drawings. The assembly shall be modified to accept the A1000 inputs for the level axes accelerometers in place of the present A200D accelerometers. The original Quantizer scaling accuracy, tracking and tolerances are to remain unchanged. The modifications are included in the red lined drawings attached. The drawings and areas of change are defined.

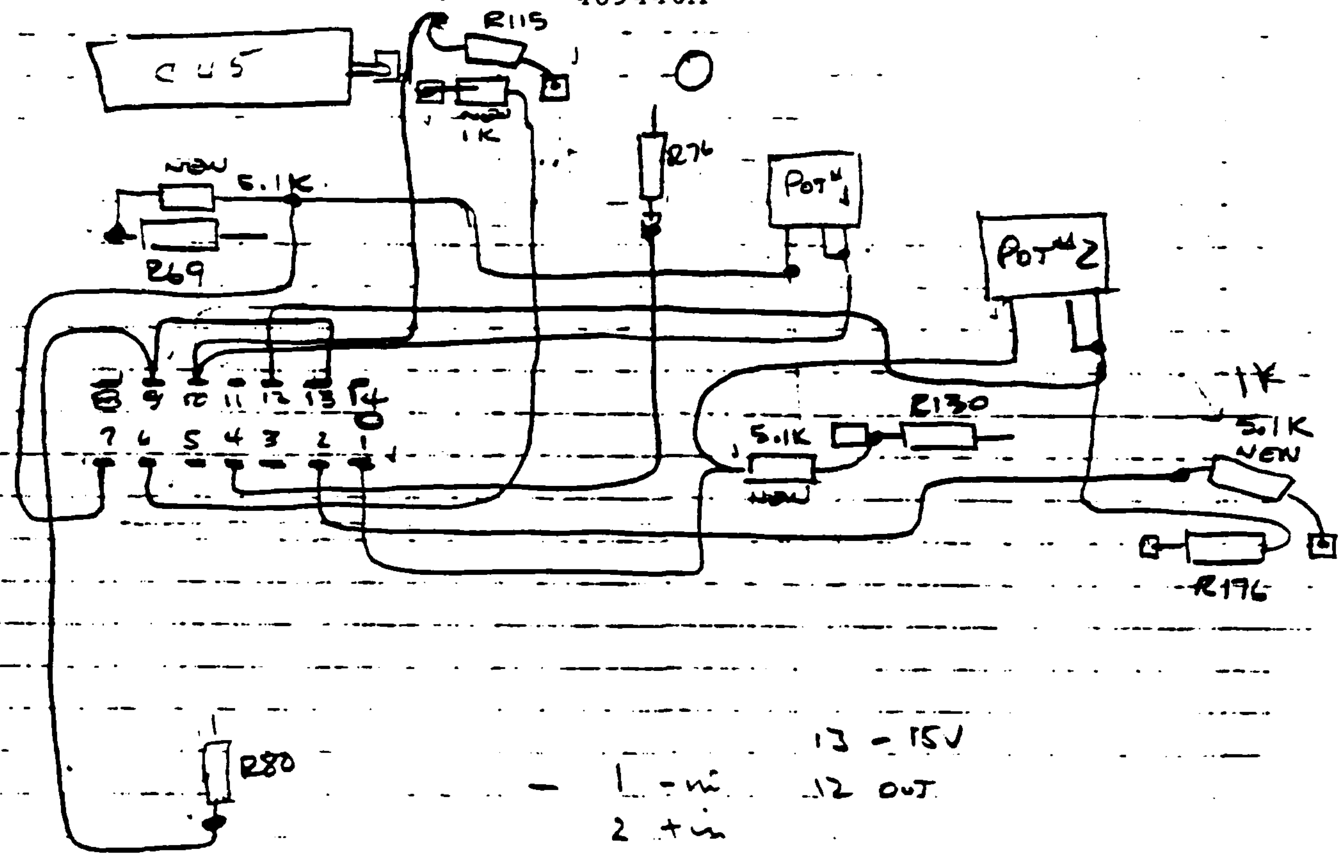
	NOMENCLATURE	DWG. NO.	PAGES/ZONES
1.	Circuit and Assembly Quantizer	880945 T	Page 5, Zone 7G, E Page 6, Zone 2D thru G
2.	Parts List	PL. 880945 T	Pages 4, 9, 10
3.	Engineering Spec.	880947	Pages 6, 7, 13, 14, 15 16, 20, 21.

J. Welch

JW:mn

Attachment: Project Office Only

469440A



13 - 15V

1 - in

12 OUT

2 + in

4 GND

+ 6 ± in

7 = in

10 OUT

9 + 15V

3597 - 4060 / 4501

2149 -

955 41e

Remove	Replace with.
C34, C35, C36 C60, C61, C62	None
Remove R112, R103, R164, R173	944738-0028 (RNC90Y1K0650BM)
Remove R287, R284, R297, R295	944738-0057 (RNC90Y88R700BM)
Remove R111, R102, R165, R172	944738-0024 (RNC90Y110R00BM)
Remove R58, R119	944739-0028 (RNC90Y200R00TM)
Remove R289, R282, R290, R297	944738-0031 (RNC90Y536R00BM)
* Remove R288, R283, R291, R296	944738-0032 (RNC90Y604R00BM)

TILLIE - EWO - 995916
ALSO STILL MISSING 2 OF THE RESISTORS WITH THE *

THANKS - JACK

Litton GUIDANCE & CONTROL SYSTEMS

469440A

ELECTRICAL CHANGE NOTICE

ECN № 143844

SCHEMATIC

PROJECT	UNIT	MODULE	ASSEMBLY TO BE CHANGED	SHEET
RG55	IMU	QUANTIZER		1 OF 2

REASON FOR CHANGE

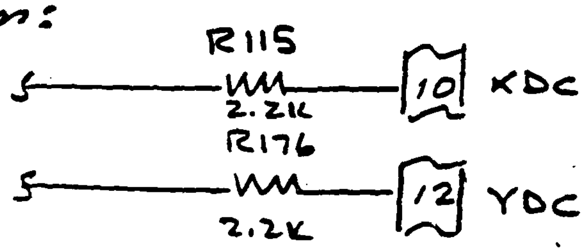
INTERPOLATOR SCALE FACTOR INCORRECT

DRAWINGS AFFECTED	SYSTEM YES	SYSTEM NO	UNIT YES	UNIT NO	MODULE YES	MODULE NO
SCHEMATIC CHANGE	☐	☒	☐	☒	☒	☐
ES/ATS CHANGE	☐	☒	☐	☒	☒	☐
TEST EQUIP CHANGE	☐	☒	☐	☒	☐	☒
ABM CHANGE	☐	☒	☐	☒	☒	☐
ARTWORK CHANGE	☐	☒	☐	☒	☒	☐
ASSEMBLY DWG CHANGE	☐	☒	☐	☒	☒	☐
WIRE LIST CHANGE	☐	☒	☐	☒	☒	☐

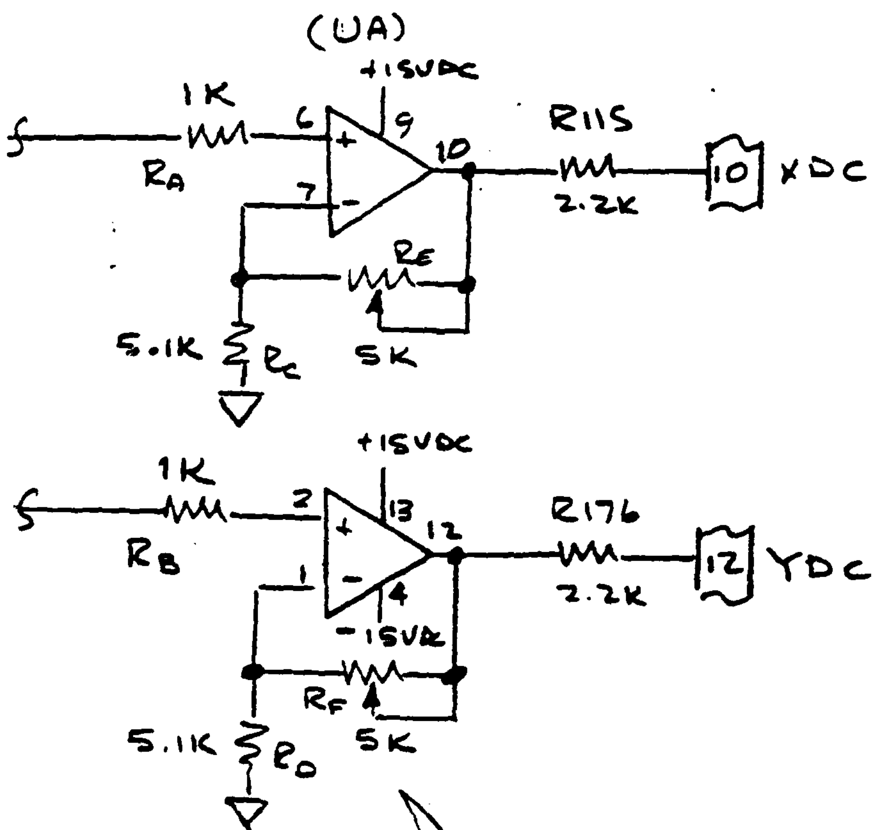
DESCRIPTION OF CHANGE:

SCHEMATIC

CHANGE FROM:



TO:



PREPARED BY	DATE	SYSTEMS ENGINEER	DATE	DEPT MANAGER	DATE
Weiss	1.14.86	[signature]	1.14.86		

PROJECT OFFICE	DATE	MECH ENGRNG ACCEPTANCE	DATE

FORM 28-483 (R6-74)

GUIDANCE & CONTROL SYSTEMS
Litton 5500 Canoga Avenue Woodland Hills, California 91364

469440A

ECN No. 143844

ELECTRICAL CHANGE NOTICE

Sheet 2 of 2

DESCRIPTION OF CHANGE: (Continued)

PARTS LIST

CHANGE ITEM 106 TO QTY 7 - ADD RA, RB (944917-1001)

ADD NEW ITEMS

QTY				
2	RLR07C5101GR (5.1K)	RESISTOR	944917-5101	RC, RD
2	M55015/3-009WR (5 K)	RESISTOR	944257-0933	RE, RF
1		DUAL OPAMP 747	974045-0421	UA

GUIDANCE & CONTROL SYSTEMS

469440A

ELECTRICAL CHANGE NOTICE

ECN № 143852

SCHEMATIC
880945

PROJECT	UNIT	MODULE	ASSEMBLY TO BE CHANGED	SHEET
RG SS	IMU	QUANTIZER	880945	1 OF 1

REASON FOR CHANGE

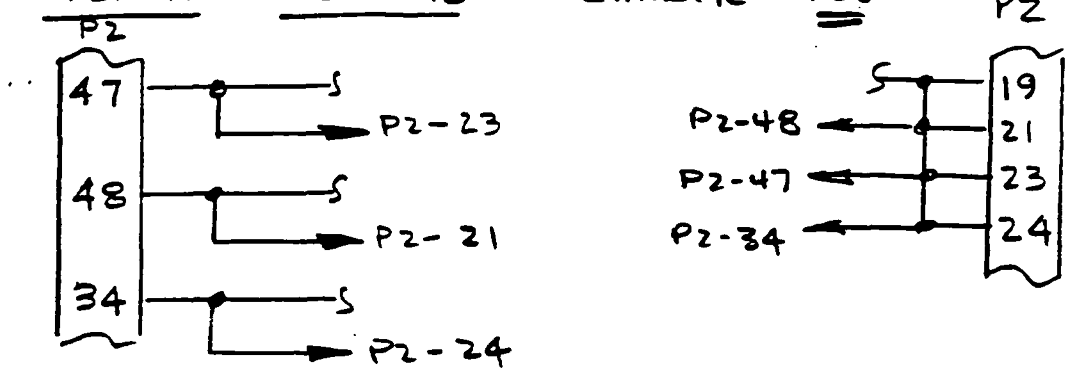
ISOLATION OF ACCELEROMETER RETURNS

DRAWINGS AFFECTED	SYSTEM YES	SYSTEM NO	UNIT YES	UNIT NO	MODULE YES	MODULE NO
SCHEMATIC CHANGE	☐	☒	☐	☒	☒	☐
ES/ATS CHANGE	☐	☒	☐	☒	☐	☒
TEST EQUIP CHANGE	☐	☒	☐	☒	☐	☒
ABM CHANGE	☐	☒	☐	☒	☐	☒

DRAWINGS AFFECTED	SYSTEM YES	SYSTEM NO	UNIT YES	UNIT NO	MODULE YES	MODULE NO
ARTWORK CHANGE	☐	☒	☐	☒	☐	☒
ASSEMBLY DWG CHANGE	☐	☒	☐	☒	☒	☐
WIRE LIST CHANGE	☐	☒	☐	☒	☐	☒

DESCRIPTION OF CHANGE:

SCHEMATIC 880945 CHANGE TO:



ASS'Y 880945

ADD JUMPERS

P2-34 IV to P2-24 IV

P2-48 IV to P2-21 IV

P2-47 IV to P2-23 IV

PREPARED BY	DATE	SYSTEMS ENGINEER	DATE	DEPT MANAGER	DATE
Welch	3.10.86	[signature]	3.10.86		

PROJECT OFFICE	DATE	MECH ENGRNG ACCEPTANCE	DATE

FORM 28-483 (R6-74)

469440A

GUIDANCE & CONTROL SYSTEMS

Litton

OFFICE CORRESPONDENCE

COPIES TO: F. Dunkel
J. Eckenrode
R. Fuller
G. Manoly
G. Stevens
R. Toler
W. Waterhouse
W. Weber

FILE: RGSS 16.0/4

DATE: 13 December 1984

SUBJECT: A1000 ACCELEROMETER HOUSING

TO: RGSS Design File LOC.: EXT.:

FROM: J. Welch LOC. 76/37 EXT. 3587

The original accelerometer housing 786256 was reviewed for form and fit into the 680052 azimuth mouting block and found to be deficient. A new housing assembly was designed (copy attached) which will allow A200 heaters and the Pads Z accelerometer flex print (880877) to be added. The overall assembly will be designed at a date TBD. The vellums are in possession of F. Dunkel until such time as design can be verified as fixed.

J. Welch

JW:jd

Attachment: Design File only

469440A

COPIES TO:
J. Eckenrode
B. Edwards
R. Fuller
J. Krantz
G. Stevens
W. Weber
W. Waterhouse
C Welch

OFFICE CORRESPONDENCE

FILE: RGSS ~~16.0/8~~ 16.8/1

DATE: 21 January 1985

SUBJECT: G300 Gyro Mass Unbalance Compensation Using A1000 Accelerometers

---

TO: Design File

FROM: J. Welch   LOC: 76   EXT: 3587

Existing G300 gyro uncompensated 'g' sensitive drift rates can vary up to 8 degrees per hour per 'g'. This term has been compensated at the gyro level using a resistor kit and a d.c. voltage representing the A200D accelerometer amplifier output of 1.72 VDC per 'g'.

Use of the A1000 accelerometer with the G300 gyro will require an amplifier to increase the A1000 output of a nominal 0.3 v/g across a precision resistor of 200ohms to a nominal 1.72 VDC/g and provide buffering such that the acclerometer-quantizer loop is not dynamically affected. The gyro load the amplifier will look into is stable, but can vary from 2.8 K to infinity. The new amplifier will mount on the gimbal stable element assembly in the area vacated by the A200 preamplifier assembly. The temperature of the stable element shall be maintained at 151F° ± 1°F. The following prints may be used for references.

a.) 679574 G300 schematic
b.) 880986 A200 Accelerometer E.S.
c.) 679765 A1000 Accelerometer E.S.
d.) 681184 A200 Restoring Amplifier Assy. (for footprint)

The amplifier gain shall remain stable to 0.5% for each turn on after thermal stabilization (1 hour). System level calibration shall eliminate long term trending requirements.

J. Welch

/jr

MAX G INPUT 6

OUTPUT SHALL BE NON INVERTING

OFFSET EFFECT ON QUANTIZER ~~±.02~~% -(μg's) ≤ 10μg (.3μg/°F)

±15VDC ± .02%

±28VDC ± 4% RIPPLE < 1 VPP

2 channels - (identical unit)

SF effect TO CURRENT .01%

Need quantizer GND - check for both channels.

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OFFICE CORRESPONDENCE

FILE: RGSS 16.8/1A

DATE: 4 February 1985

SUBJECT: GYRO MU COMPENSATION AMPLIFIERS

TO: Design File **LOC:** **EXT:**

FROM: J. Welch **LOC:** 76/37 **EXT:** 3587

Please add to previous memo RGSS 16.0/8 the following info.

Max accleration - 6 g
Output - noninverting
Offset effect on quantizer - $\leq 10\ \mu g$ and
Offset effect (thermal) - .3 $\mu g/^{\circ}F$
Power - available ± 15 VDC $\pm .02\%$
± 28 VDC $\pm 4\%$
Amplifier shall have Z channels (Z accel and Y accel)

J. Welch

JW:jd

469440A

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OFFICE CORRESPONDENCE

FILE: LASS II 16.8/15
16.3/7

DATE: 23 April 1985

SUBJECT: MASS UNBALANCE COMPENSATION AMPLIFIER

TO: Design File LOC.: EXT.:

FROM: J. Welch LOC. 76/37 EXT.: 3587

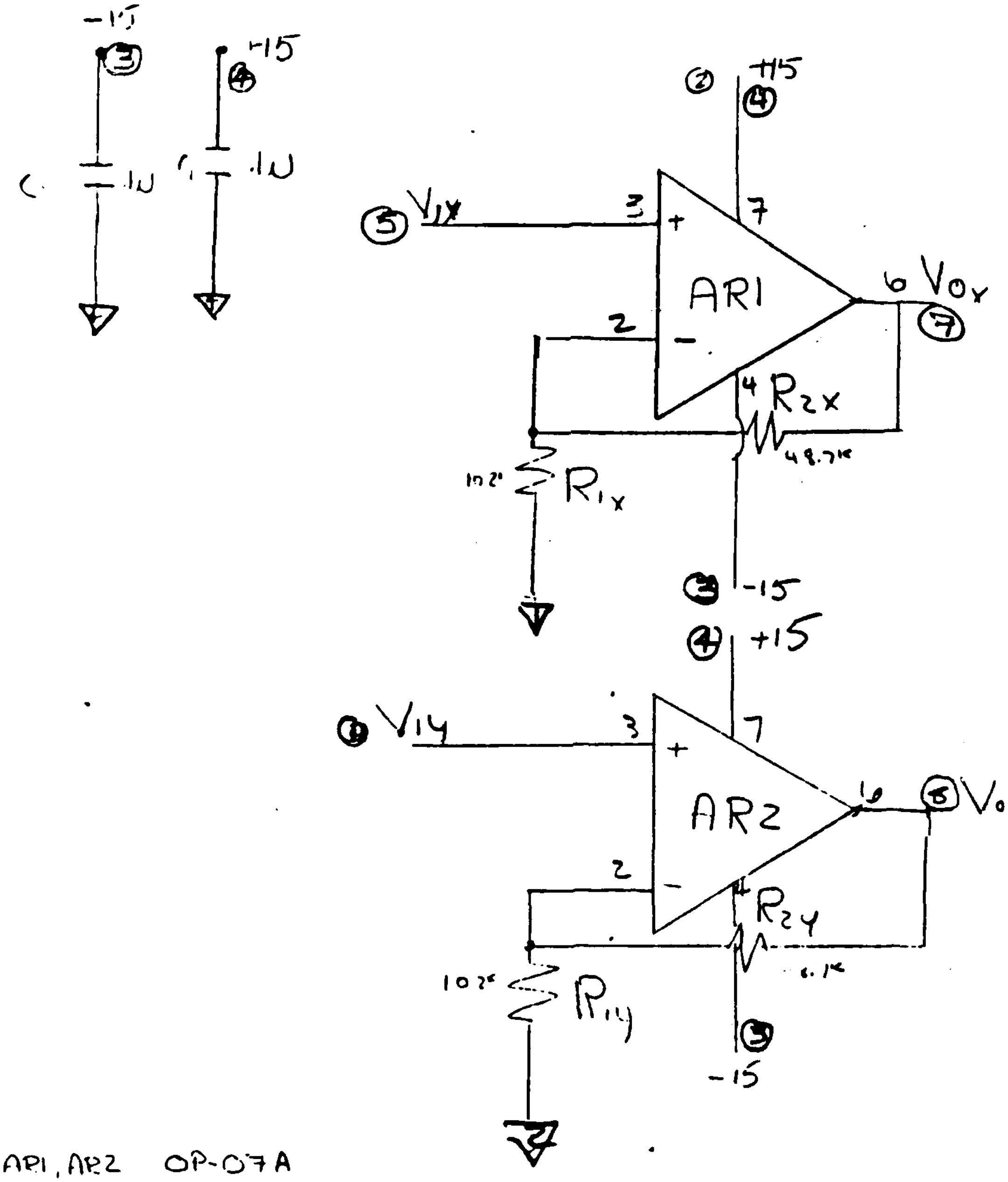
To facilitate the drawing package the following pin out for the Mu Comp Ampl shall be used.

Pin	Signal
1	X Accel Gnd
2	Y Accel Gnd
3	-15VDC
4	+15VDC
5	X Accel Input
6	Y Accel Input
7	U.G. Comp SA/and LG Comp HA/VA
8	U.G. Comp HA/VA and LG Comp SA

The assembly and schematic number are 867942.

J. Welch

JW:jd



AR1, AR2 OP-07A
R_{1x}, R_{1y} RNC50
R_{2x}, R_{2y} RNC50
C_1, C_2 M39014/1-15

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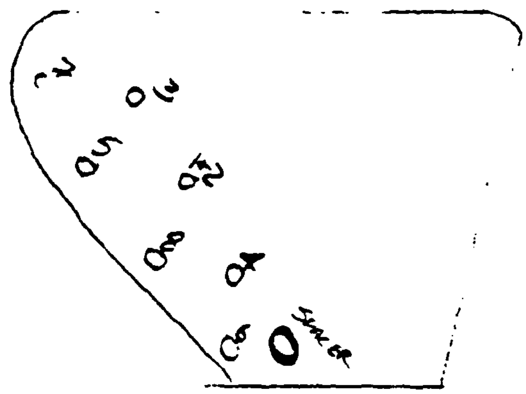
5500 Canoga Avenue, Woodland Hills, California 91365

FSCM 06481

MASS UNBALANCE COMPENSATION AMPLIFIER PIN OUT



SPACER:
BLACK ON WHITE
SPACER ON EDGE
OF BOARD

Y ACCEL INPUT — 6

+15VDC — 4

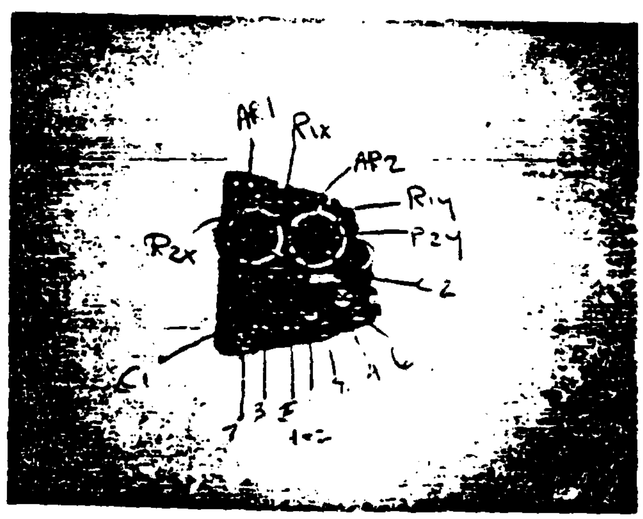
Y CHAN OUT — 8

GROUND — 1+2

X ACCEL INPUT — 5

-15VDC — 3

X CHAN OUT — 7



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COPIES TO:

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OFFICE CORRESPONDENCE

FILE: LASS II 16.3/4

DATE. 19 April 1985

SUBJECT: RGSS ACCELEROMETER HEATER CIRCUIT MODIFICATION

TO:	Design File	LOC.:		EXT.:	
FROM:	J. Welch	LOC.	76/37	EXT.:	3587

The circuit modification to drive the accelerometer heat to 185°F has been completed. The new drawings associated with this package are:

1) Accelerometer temperature control amplifiers ES 864418.

2) Schematic diagram, electronic, accelerometer temperature control amplifiers 864417.

3) Accelerometer temperature sensor 864416.

J. Welch

JW:jd

Attachment - Project Office only

469440A

COPIES TO:

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OFFICE CORRESPONDENCE

FILE: RGSS 16.4/4

DATE: 3/7/85

SUBJECT: Instrument Requirements RGSS

TO: LASS Design File LOC.: EXT.:

FROM: J. Welch LOC. 76 EXT.: 3587

This memo shall replace Memo RGSS 16.6/1 in its entirety. The RGSS gyros shall be screened at SLC for the standard LASS II gyro, part number 659730-6 (ES880977) with the following exceptions. Instrument Engineering Engineering at Woodland Hills shall verify and/or screen further, those functions as indicated.

Applicable Paragraph	Test SLC	Test W.H.	Function	Reqt's Differing From ES 880977
3.3.1.5.2	✓	✓	Flotation Temperature	0.5 °F to 1.5 °F
3.3.2.3	✓	✓	Random Drift Now-trend turnon + 1 hour to turnon + 8 hours	IG = 0.0001± 0.0002°/HR^2 O.G. + 0.0003± 0.0005°/HR^2
3.3.2.4.2.1		✓	Slew Repeatability	NONE
3.3.2.5	✓		Temperature Sensitive Drift rate	H.A. = 0.01°/Hr/°F V.A. = 0.015°/Hr/°F
3.4.1.1 3.4.1.2	✓ ✓		Torquer Alignments (majority true one axis)	<60 sec both axes
3.4.2.1 3.4.2.2	✓ ✓		Spin Axis Alignment	<30 sec both axes
3.3.4.2.3		✓	Bias stability long term 30 day	H.A. = <0.0005°/Hr/Da[y] V.A. = <0.001°/Hr/Day
NONE		✓	Cross Axis Sensitivities for 2000°/Hr rate on the vertical precession axis	H.A. precession Axis drift = <1°/Hr
NONE	✓		Torquer scale factor variation long term	<0.02% over 90 days
NONE	✓ *1		Torquer scale factor temperature sensitivity	<0.03%/°G
NONE		✓ *2	Torquer scale factor Assymetry	<0.01%

Check for absolute rech

- .03 to .05%

*1 A temperature bias control on the test equipment will allow a few degrees change. This is sufficient to characterize the error source.

*2 Information gleaned from the raw data processing prior to the scale factor averaging can be obtained.

All bias, slew and torque data recorded in analog format on charts shall be reviewed for bias trending, noise, steps and other anomolies.

The total number of gyros required to support the RGSS program shall be four (4). The instruments shall be usable in either the upper or lower positions.

691200-711 469440A

 Look into -7 Amplifier gives < 15 mv RMS

Get noise spec

Accelerometer

The RGSS accelerometer shall be screened at SLC for the PADS accelerometer, part number 679770-6 (ES679765) with exceptions as noted. The engineering labratory at Woodland Hills shall provide verification of SLC screening, and additional screening as well. The estimated quantity of accelerometers to support the program is six (6). The accelerometers shall be capable of being placed in X, Y or Z positions.

Tuning station 150°

Applicable Paragraph	Function	Requirements differing from ES679765
3.1.1.	Operating Temp.	151 ±2°F check 36C
3.4.2.2	Bias Stability	<10 μg 1σ at operating Temp (151°F)
* 3.4.2.3	Bias Temp. Sensitivity	~~2~~ 1.5 μg/1°F between ~~140~~°F 150°F and ~~160~~°F 190°F
3.4.2.5	Bias Cage - Uncage Repeatability	<10μg
3.4.3	Scale Factor	0.300 ± .003 v/g across 200Ω ± .001°/o
3.4.3.2	Scale Factor Non linearity (Kii)	<50μg/g² 0-4g's
3.4.3.4	Scale Factor Long Term Stability	<200 PPM/30 days *
3.4.4	Axes Alignment	<30 sec

Software correction to FTE

Engineering shall further check and or verify

~~3.4.1~~ 3.1.4	Threshold Acceleration	1μg
3.4.2.2	Bias Stability	Random drift 1-6 hours
	Bias Repeatability	<10μg at temperature turn-off-turn-on
	Hinge Creep	Turn on +20 minutes Creep shall be non identifiable
	Overnight drift runs	Monitor for abnormalities including spurious noise spikes and bias steps.
	Scale Factor asymmetry	Monitor and obtain asymmetri value.

Check ~~FTE~~ AC component - use -7 spec - for value. noise limits

* . Can be included with hinge creep.

* HP-Computer- (G1200 funds) 125's - for Woodland Hills - /FTE to put temp mod for thermal -

Vibration linearity tests - rectification check for most tests @ WH

Instrument Engineering should be aware of a possible series of instrument retests, dependent upon system level performance and customer requirements undefined at this time.

J. Welch

469440A

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OFFICE CORRESPONDENCE

FILE: RGSS 16.4/4A

DATE: 17 June 1985

SUBJECT: INSTRUMENT REQUIREMENTS RGSS

TO: Design File LOC: EXT:

FROM: J. Welch LOC 76/37 EXT. 3587

This memo shall be a revision to the accelerometer requirements as defined in the original memo.

¶3.4.1 Accelerometer AC Output <3mv P-P At Temp (151°F)

This check to be made at SLC and W.H.

Scale factor Kii and long term scale factor, paragraphs 3.4.3.2 and 3.4.3.4 to be tested by Woodland Hills in lieu of SLC.

All data in the form of machine printout, manually taken, and plotted shall be delivered with each accelerometer.

J. Welch

JW:jd

4C9007

Bias Sens 2.29 µg/g

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COPIES TO: Attached distribut:

OFFICE CORRESPONDENCE

FILE: RGSS 16.4/4B

DATE: 30 August 1985

SUBJECT: INSTRUMENT REQUIREMENTS RGSS

TO: Distribution LOC: EXT.:

FROM: J. Welch LOC. 76/37 EXT. 3587

This memo is intended to provide Accelerometer temperature testing relief at SLC due to A1000 Final Station peculiarities.

Para. 3.4.2.3 Bias Temperature Sensitivities shall be checked at the existing station points of 150, 170 and 190°F. With the sensitivity reduced from 2μg/°F to 1.5°μg/°F.

All other testing to be accommodated at or around 150°F as before.

J. Welch

JW:jd

469440A

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OFFICE CORRESPONDENCE

COPIES TO: J. Eckenrode
G. Manoly
J. Nielsen
D. Stevens
G. Stevens
R. Toler
W. Waterhous
W. Weber

FILE: LASS 5.15/1

DATE: 30 October 1984

SUBJECT: RGSS LEVEL AXIS ACCELEROMETER

TO: Design File LOC.: EXT.:

FROM: J. Welch LOC. 76/37 EXT. 3587

The RGSS level axis accelerometers are to be A1000 assemblies P/N 679770 mounted within a case similar to or identical to assembly P/N 786256. External heaters will be required, and existing parts 972244 and 972245 are the preferred devices. The accelerometers, X and Y shall mount into the existing mounting block assembly 680052. If required, milling of the block assembly in the vicinity of the accelerometers (level axis) may be required to facilitate accel mounting. The following mounting surface reference accuracies are required. A1000 accelerometer mounting surfaces X to Y to Z of ± 100 sec. This will include all non parallel discrepancies between the A1000 cases, mounting cases and the mounting block assembly.

J. Welch

JW:jd

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ELECTRICAL CHANGE NOTICE

ECN № 143843

SCHEMATIC 864417

PROJECT	UNIT	MODULE	ASSEMBLY TO BE CHANGED	SHEET
RGSS	IMU	TEMP CNTL AMP	864416	1 OF 3

REASON FOR CHANGE

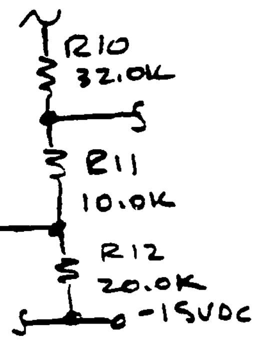
REQTS CHANGE O.T. SENSOR CHANGED TO 100K FROM 15K

DRAWINGS AFFECTED	SYSTEM YES	SYSTEM NO	UNIT YES	UNIT NO	MODULE YES	MODULE NO
SCHEMATIC CHANGE	☐	☒	☐	☒	☒	☐
ES/ATS CHANGE	☐	☒	☐	☒	☒	☐
TEST EQUIP CHANGE	☐	☒	☐	☒	☐	☒
ABM CHANGE	☐	☒	☐	☒	☒	☐
ARTWORK CHANGE	☐	☒	☐	☒	☐	☒
ASSEMBLY DWG CHANGE	☐	☒	☐	☒	☒	☐
WIRE LIST CHANGE	☐	☒	☐	☒	☐	☒

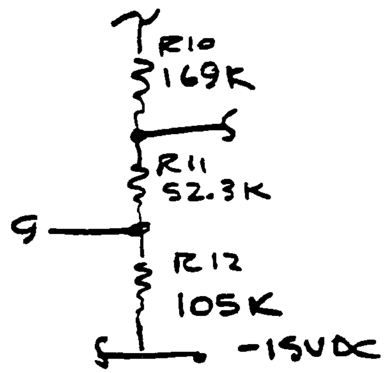
DESCRIPTION OF CHANGE:

SCHEMATIC 864417

CHANGE FROM:



TO:



LIST OF MAT'L

R10	32.0K	0.1	1/20W
R11	10.0K	0.1	1/20W
R12	20.0K	0.1	1/20W

LIST OF MAT'L

R10	169K	0.1	1/20W
R11	52.3K	0.1	1/20W
R12	105K	0.1	1/20W

ASSY 864416 PARTS LIST

Change From:

35	RNC50J3202BM	944108-3202
34	RNC50J2002BM	944108-2002
32	RNC50J1002BM	944108-1002

TO:

35	RNC50J1693BS	944117-1693
34	RNC50J1053BS	944117-1053
32	RNC50J5232BS	944117-5232

PREPARED BY	DATE	SYSTEMS ENGINEER	DATE	DEPT MANAGER	DATE
		[signature]	25 Nov 85		

PROJECT OFFICE	DATE	MECH ENGRNG ACCEPTANCE	DATE

FORM 28-483 (R6-74)

GUIDANCE & CONTROL SYSTEMS
Litton 5500 Canoga Avenue Woodland Hills California 91364

ECN No. 43843

ELECTRICAL CHANGE NOTICE

Sheet 2 of 3

DESCRIPTION OF CHANGE: (Continued)

ES 864413

CHANGE FROM

TABLE 1

Temperature °F	Pin 9 to Pin 4 KΩ (±0.1%)	V Pin 5 ± Tol. Volts
Δ-65	887.122	9.6367 ±0.100
-50	521.200	9.4077 ±0.100
-45	439.500	9.3063 ±0.100
-40	370.600	9.1969 ±0.100
Δ-35	314.700	9.0526 ±0.100
-30	267.200	8.8967 ±0.100
-25	228.200	8.7240 ±0.100
-20	194.900	8.5247 ±0.085
-10	143.600	8.0517 ±0.106
0	106.900	7.4610 ±0.129
10	80.440	6.7615 ±0.153
20	61.070	5.9286 ±0.179
30	46.810	4.9730 ±0.202
40	36.200	3.9075 ±0.222
50	28.250	2.7538 ±0.273
60	22.210	1.5349 ±0.247
Δ 70	17.580	0.2798 ±0.250
80	14.030	-0.9675 ±0.245
90	11.290	-2.1744 ±0.236
100	9.130	-3.3317 ±0.224
110	7.430	-4.4118 ±0.206
120	6.087	-5.3932 ±0.187
130	5.018	-6.2781 ±0.167
140	4.160	-7.0651 ±0.148
150	3.467	-7.7591 ±0.130
Δ153	3.287	-7.9488 ±0.122
160	2.903	-8.3668 ±0.113
170	2.447	-8.8898 ±0.098
180	2.070	-9.3453 ±0.085
Δ190	1.758	-9.7385 ±0.073
200	1.501	-10.0755 ±0.067

ΔPreferred test temperatures

Form 28-484 (R7-74)

GUIDANCE & CONTROL SYSTEMS
Litton 5500 Canoga Avenue Woodland Hills California 91364

ECN No. 143643

Sheet 3 of 3

ELECTRICAL CHANGE NOTICE

DESCRIPTION OF CHANGE: (Continued)

ES 864418

CHANGE TO:

TABLE 1

T(°F)	PIN 9 to PIN 4 (± 0.1%)	V PIN 5
-65	9.579 Meg	+ 9.6443 ± 0.3%
32	336300	+5.9178
50	202200	+4.0095
77	100000	0.5479
140	24170	-6.8144
150	19750	-7.6221
153	18640	-7.8375
160	16260	-8.3176 ± 0.3%
170	13438	-8.9219 ± 0.2%
180	11188	-9.4333 ± 0.2%
190	9330	-9.8772 ± 0.2%
200	7844.4	-10.2471 ± 0.3%

Form 28-484 (R7-74)